The Blast Furnace and Steel Plant

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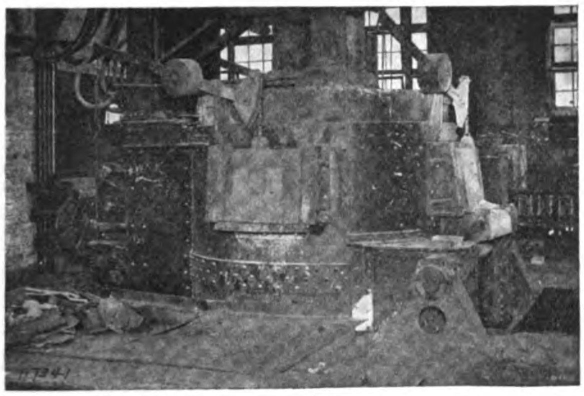
UNIVERSITY OF MICHIGAN

The Blast Furnace and Steel Plant

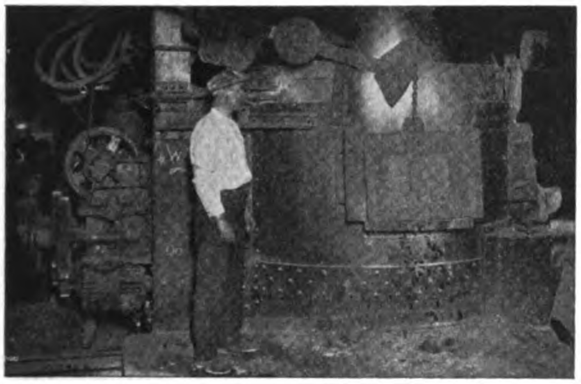
Performance of Small Electric Furnace

Description of Operation and Equipment of a Two-Ton Electric Furnace Installed at the Driver-Harris Company Plant Chiefly for the Production of Nichrome.

An electric furnace, whose main product is nichrome, the well-known high-temperature resisting alloy, has recently been installed at the plant of the Driver-Harris Co., Harrison, N. J. The furnace is of special interest because of its electrical equipment, which is an excellent example of modern practice. Alloys of various characters are also manufactured by the furnace. It is of the Heroult Arc type, featured with automatic regulation, and has a capacity of two tons.

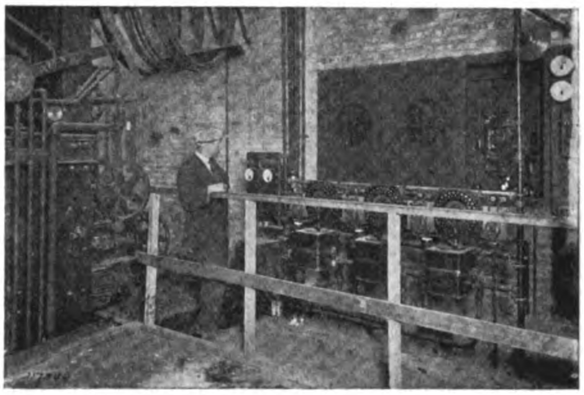

View of 2-ton Heroult Electric Furnace.

The amount of power taken at the start of the heat is small in both cases, but as the resistance of the furnace circuit decreases, owing to the heating up of the electrodes and the consolidation of the charge, the power consumption rapidly increases until stable conditions are reached. The average amount of power consumed is then held practically constant by the automatic regulator, with the exception of a slight continuous increase due probably to a corresponding decrease in the resistance of the furnace circuit.

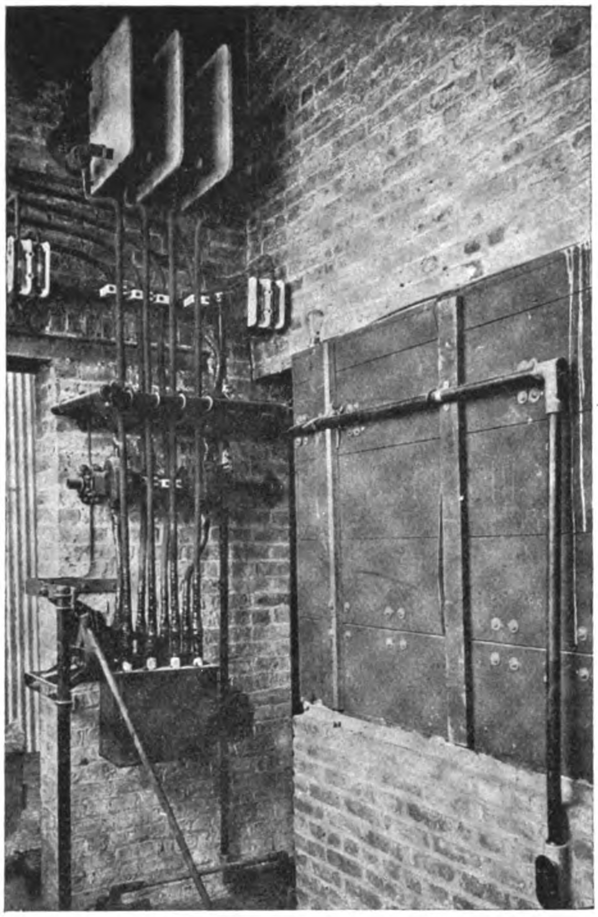

Night view—In operation.

Filling moulds.

There is, however, no uniformity in the actual power consumption. As the charge melts down, pieces of metal fall in between the electrodes and establish short circuits. For the most part these short circuits

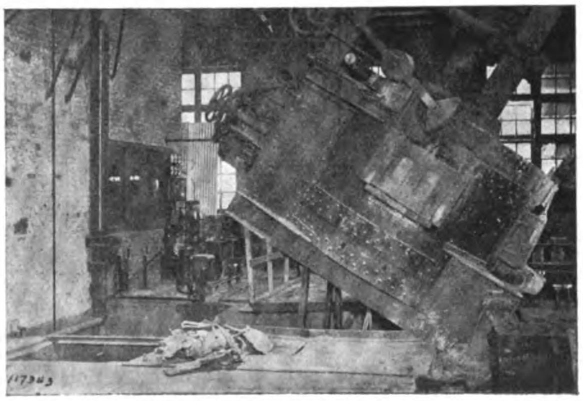

Thury Regulator.

are only momentary as the fragments causing them are promptly melted down, but occasionally they persist and then the automatic regulator draws up the electrodes until they are clear. This process sometimes breaks the arc and then there is a sudden decrease in the power consumption until the regulator brings the electrodes down again and re-establishes the arc. As would be expected the nickel steel alloy shows more of these irregularities than the softer nichrome.

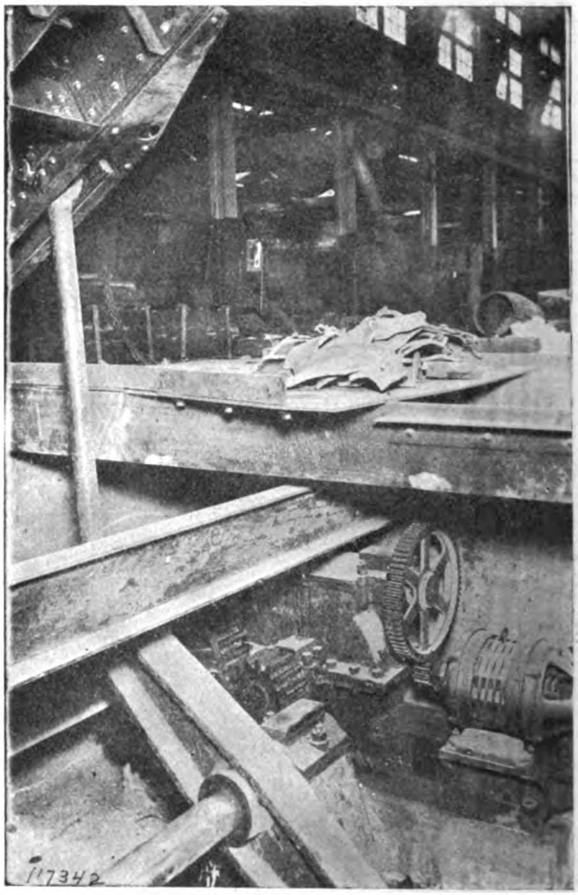


Type F. breaker, 2,200 volts. Disconnecting switches above.

Towards the end of the run there is a marked change in the power consumption when the metal is given a special treatment before pouring. In the case of the nickel steel a higher temperature was necessary, perhaps to lower the carbon content, while with nichrome the temperature was lowered. The temperature of the furnace averages about 2,200 degrees F.



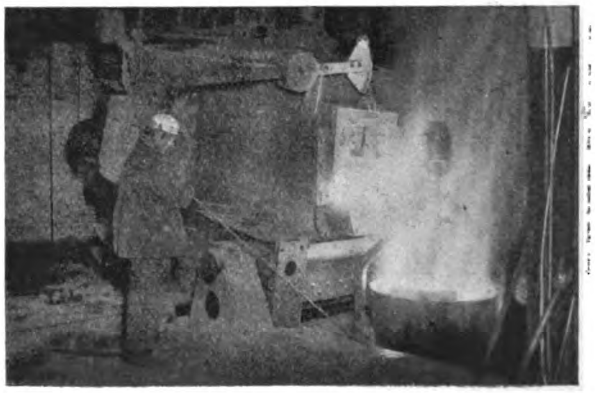
View of furnace tilted for pouring.



11 H. P. Westinghouse type CW tilting motor.

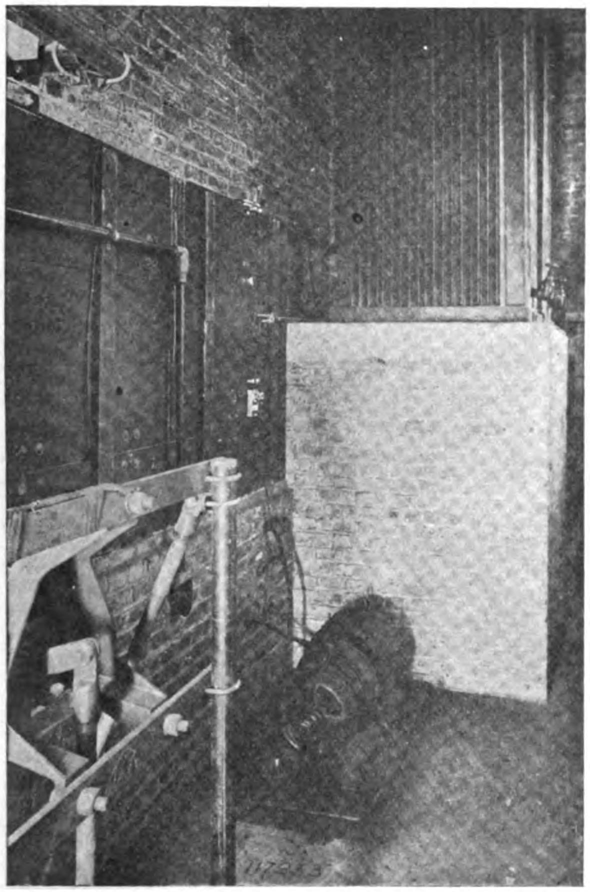
The high momentary overloads are characteristic of electric furnace work and make it very different from ordinary power service. They must be taken into account in designing the electrical equipment for the furnace, and some of the apparatus must be especially designed to withstand them, as shown in the following description of the Driver-Harris installation.

Power for this furnace is furnished in the form of



Pouring.

two-phase, 60-cycle, 2,200 volt-current from the lines of the Public Service Electric Company. In the high tension lines are, a disconnecting switch and an oil circuit breaker. The latter is used to control the circuit. It can be operated manually and is also provided with low-voltage and overload protection. In order to prevent its operation on momentary overloads, the overload trip is controlled by relays with definite inverse-time-limit action. The high tension apparatus and the transformers are contained in a brick compartment behind the furnace.



4½ kw. Westinghouse MG set for supplying direct current for Thury regulator and electrode operating motors.

There are two 400-kvs, 2,200/110-volt transformers of the oil-insulated self-cooled type. They are Scott-connected so that they change the high-voltage two-phase current into low-voltage three-phase current, one phase for each of the three electrodes of the furnace.

Special construction is necessary to withstand the overloads. These overloads are of such duration that their heating effect is negligible but they tend to force the coils apart. Hence the coils are very firmly braced and are in fact capable of withstanding momentary overloads fifteen times greater than the normal load.

The reactance of these transformers is about double that of ordinary power transformers of the same size. This reactance together with that developed in the low tension leads (which are made as short as possible in order to keep this factor low) prevent the current flowing through the furnace from exceeding five or six times normal values even on dead short circuits. The voltage regulation is from 106 volts on no load to about 100 volts on full load, and the power factor is from 85 to 90 per cent.

One of the most interesting features of the equipment is the Thury regulator, which automatically maintains an approximately constant current at the furnace electrodes. Without this device the current consumption would vary eratically even if an operator were constantly endeavoring to correct the variations. It therefore saves labor and current, reduces to a minimum the time required to prepare a charge, and by providing uniform conditions, keeps the quality of the product uniform.

Each furnace electrode has a separate regulating mechanism and a raising and lowering motor. The regulator can be set for any desired current value and when this value is exceeded, each regulating mechanism closes a contact momentarily which causes the motors to raise the electrodes slightly. The contacts continue to close at brief intervals until the electrodes are drawn up high enough to reduce the current to the predetermined value, the intermittent action being employed to prevent the electrodes from being raised too high and thus causing an unstable condition. When the current falls below the predetermined value the electrodes are lowered in a similar manner. The regulator itself is controlled by a solenoid energized by means of current from series transformers in the main high-tension circuit. Damping devices prevent the regulator from acting on overloads that immediately correct themselves.

In addition to the automatic device, each electrode motor has a drum controller for manual operation.

The electrode motors are direct-current machines, because alternating-current motors cannot be controlled with sufficient delicacy. The operating current is obtained from a 4½ KW motor-generator set located in the transformer compartment. The motors are of 2 H.P. capacity and are totally enclosed; they are provided with grease-cup lubrication instead of the ordinary ring-oiling system so that the lubrication is not interfered with when the furnace is tilted for pouring.

An instrument board is located beside the regulators and carries the following apparatus: A kilowatt meter; a voltmeter; a power factor meter; an ammeter for each phase; a graphic wattmeter; a plug switch for reading the voltage of each phase, both across the arc and across the low-tension leads outside the furnace; the operating handle of the high-tension circuit breaker; the inverse-time-element relays for the circuit-breaker; and an integrating kilowatt-hour meter.

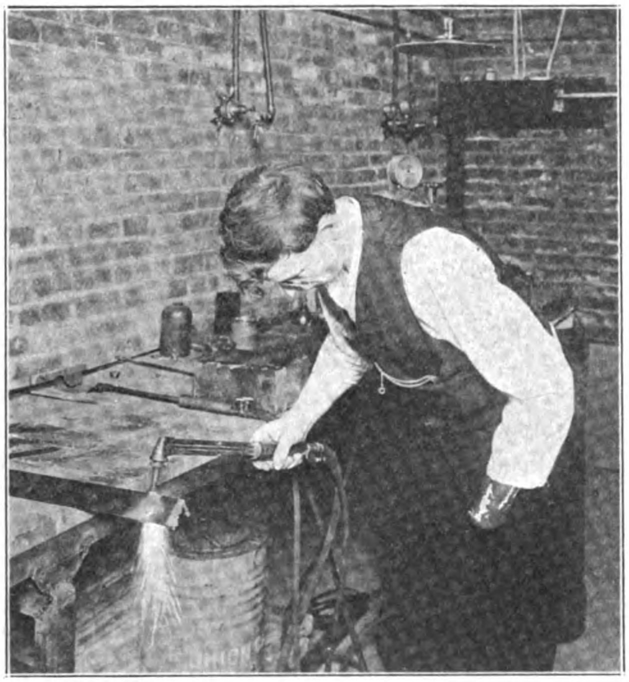
On the other side of the regulator is mounted a small panel carrying the switches and meters.

The Conservation of Industrial Man Power

The Question of Rehabilitating the Crippled Soldier So That He Can Stand on His Own Merits After the War—Operation of the Vocational Rehabilitation Act.

By ARTHUR J. WESTERMAYR, LL.M.

We are passing through a period of moral training. By suggestion, appeal and regulation the American mind is being educated to a better understanding of the economic value of conservation. It is gripping necessity plus a patriotic willingness to help win the war that makes American people respond to every call for greater and ever greater care in the use of food, clothing and money. We must conserve all the things that go into the war business if we would emerge out of the cataclysmic conflict military and moral victors.



Oxy-Acetylene Welding.

Oxy-Acetylene Laboratory.

And while we are digesting the wisdom of all kinds of conservation, we should not ignore the importance of the conservation of man power, for the wastage in this, greater and more serious than all other, is an after-war problem to which the best thinkers and educators have already begun to address themselves with gratifying results.

At present the man power supply is far short of the need as we are daily told by industrial leaders. As each million of men is drawn by draft from the ranks of producing workers this supply is lessening and industrial disturbance must, as it does, follow. A considerable number of those who go over will not return. Of those who do return a large percentage will come back to us bearing the honorable scars of service. And every cripple is an item of loss to the man power supply unless we make immediate preparation for the conservation of the disabled.

Our producing capacity is taxed to the utmost today; it will continue to be so taxed for a long time after the war is over, for then, as now, upon us will fall the honorable task of feeding and clothing a large part of the world besides caring for our own needs. Not one ounce of human energy can we afford to waste, for every ounce is necessary for the upbuilding and maintenance of our industrial life.

In former times the war cripple was regarded as an inevitable consequence of war and beyond making provision by pension and sporadic private charity, we did not think we owed any duty. But this is not a haphazard war. It is a scientific war and everything is being done to develop efficiency in production as well as in conservation. This same scientific spirit must apply itself to the salvage of man-power to meet the after-war pressing needs. The mendicant war cripple is today a living disgrace to the nation which permits him to exist. In the cripple there is still the potential power of production. Few are so completely maimed that by vocational re-education they cannot be made again productive.

Belgium, France, England and Canada as well as the more enlightened of our enemies have taken up this problem and are solving it with happy results to the cripple and the state in restored and self-dependent manhood, and the added production of another unit of man-power otherwise lost.

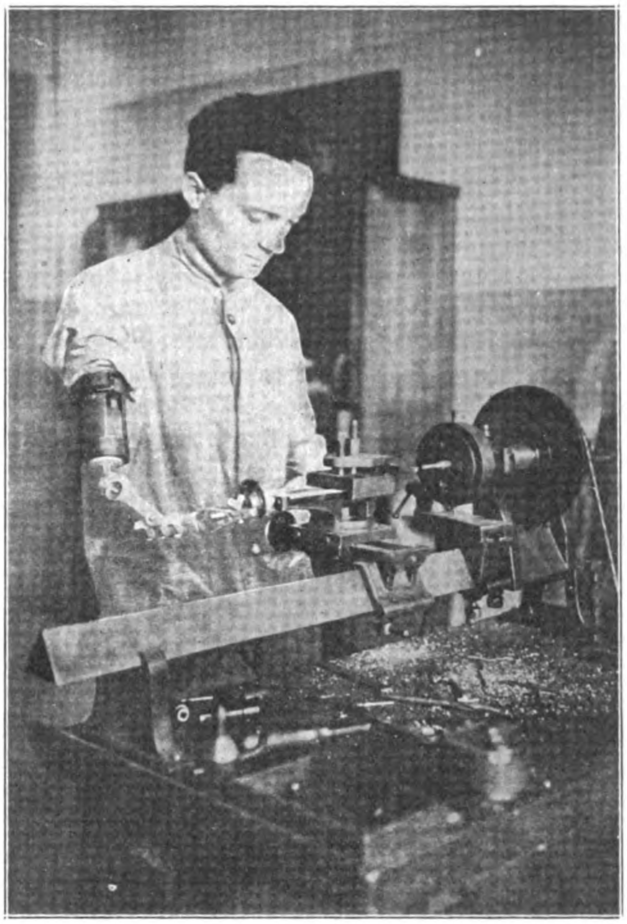
According to the vocational rehabilitation act recently enacted by congress those disabled in the military and naval forces of the United States have been placed under the joint authority of the surgeon general of the army and the Federal board for vocational education. The surgeon general has jurisdiction from the time the person is injured until he is restored to good physical condition, when he receives his honorable discharge from the service. The Federal board then offers him vocational re-education and training which will enable him to return to useful active employment, and the U. S. employment service will coöperate in finding him a job.

Charity is debasing—it lowers the moral standard and destroys self-respect. No man, however, high his principles, can long be a dependent on public or private charity without losing the finer quality of his manhood. No civilized nation can look without shame on an army of crippled beggar veterans. Soldiers' homes and kindred institutions, excellent and worthy though they admittedly are, do not quite satisfy the requirements.

The solution has been found in the vocational re-education of the cripple. In the countries mentioned the plan is being worked out and the most gratifying results are being obtained. Thus thousands of men have been rescued from the junk heap of human waste and restored to society, self-respecting, self-supporting members. True charity (if such we may call what is so obviously self-serving) is to solve the producing power of the cripple by teaching him to use his remaining powers. There is work a one-armed man can do for he has his other arm and two legs; the one-legged man with two good arms can be made productive by finding the way for him to employ his sound members. By using, as far as possible, the skill acquired in his former occupations, the cripple can speedily be re-educated and made self-supporting at least cost of time and money. It has been proven that six months or even less of intensive re-education will convert a human wreck into a skilled workman who can earn as good, if not better wages, than he earned before his incapacity .

These statements are based on personal observation in institutes already successfully established for the vocational training of cripples. The Red Cross Institute for Crippled and Disabled Men, at 311 Fourth avenue, New York City, is an example of what can be and is being accomplished by vocational re-education.

It is not desirable that sympathy or a charitable forbearance shall be extended to the cripple in the appraisement of his service or his product. He must stand up against fair competition with his more favored fellow workman, and should receive only what his producing powers are actually worth in the labor market. Employers who act in kindness rather than with strict justice are rendering the cripple a poor service if they show him the preference or favor, for this is only another form of demoralizing charity no less pernicious if less obvious.



Italian Method for Making Cripples Useful.

Thus far the attitude of organized labor toward the cripple has been most admirable, and it is safe to assume no friction will ever arise in labor unions or among workmen by reason of the induction of this new class into the ranks of labor. Labor has already spoken on the subject and what it has said is to its credit.

Every re-educated cripple, able to produce, is not only made happy by earning his own living, but is adding to the sum total of the nation's productivity—which means wealth. He is restored to the great industrial army upon whose production the nation's comfort, happiness—its very existence depend.

Ferro-Alloys, Manufacture and Properties

Alloys of Iron With Manganese, Silicon, Aluminium, Chromium, Tungsten, Molybdenum, Vanadium, Titanium, Boron and Uranium—Value of Special Steels of Paramount Importance.

By J. W. RICHARDS.

A large industry has grown up within the last 50 years, most of it within the last twenty-five years, which furnishes to steel makers, alloys of iron with some of the rarer metals, in order to introduce these rare metals into steel. Such alloys are known as ferro-alloys, because they all contain iron (ferrum); some of them, however, contain more of the rare metal than iron. They were originally made in crucibles, cupolas or blast-furnaces, but are now made principally in electric furnaces, and their manufacture is one of the principal electric-furnace industries.

They are of great importance to the steel industry. The steel maker uses them for one of two purposes: (1) As reagents to take oxygen out of melted steel and thus insure sound solid casting (ferromanganese, ferrosilicon, ferroaluminium); or (2) to put into the steel a small or large percentage of the rare metal (ferromanganese, ferrochromium, ferrotungsten, ferromolybdenum, ferrovanadium, ferrotitanium, ferrouranium, ferroboron).

Let us discuss briefly these two uses. Melted steel, just before taking from the furnace, always contains some oxygen dissolved in it (like the dissolved gas in charged soda water). If this is not removed, the casting made is more or less unsound from cavities or blowholes. The addition of a small amount of a metal with a high affinity for oxygen removes this element and makes the casting sound. Manganese (1 per cent or less) is the cheapest and most generally used reagent for accomplishing this; silicon (½ per cent or less) is more powerful but also more expensive, and is often used to supplement the action of manganese; aluminium (0.1 per cent or less) is still more powerful and still more expensive, and is used in very small quantities as a final addition to complete the action of the manganese and silicon. All steel makers use one, two or all three of these reagents; manganese and silicon in the form of ferro-alloys, aluminium more often as the pure metal, but ferro-aluminium is sometimes used.

The second use is to make special steels, that is, steels containing such quantities of the rare metal as give to them properties different from plain carbon steels deoxidized by manganese, silicon or aluminium. Thus we may make manganese steel by putting in 12 to 14 per cent of manganese, making a very tough, hard steel such as is used in mining and grinding machinery, burglar-proof vaults, etc.; chromium (2 to 4 per cent) makes a very hard tool steel; tungsten (15 to 25 per cent) makes high-speed tool steel, which cuts iron while red-hot; molybdenum (6 to 10 per cent) has powers similar to tungsten, and is also used in steel for lining large guns. Vanadium (1/10 to ½ per cent) makes very strong steel which resists shock extremely well, as when used for automobile axles; titanium, uranium and boron impart valuable properties not so easily described. Every one of these materials is used for producing some specific result which is not produced by any other; sometimes combinations of two, three or four are used in one steel, producing a particular combination of special properties for some special purpose. Some of these materials cost $5 per pound, and the special steels produced cost up to $2.50 per pound, but their particularly valuable properties justify the expense. The value of these special steels to the industries, and particularly for military purposes, is very great, so great that the supply of ferro-alloys for their manufacture is an important factor in winning the war.

Ferromanganese.

This is the oldest of the ferro-alloys. Its manufacture was begun about 50 years ago. It was first made in crucibles, has for a long time been made in blast-furnaces, but is now being produced in many places in electric furnaces. It is made with 30 to 85 per cent manganese, 3 to 5 per cent carbon, a little silicon and the rest iron. The rich grades, 75 to 85 per cent, are preferred by the steel maker, but they require rich manganese ores for their manufacture. The United States has very little rich manganese ore, but large quantities of low-grade ores; one of the present burdens of the steel maker is to use low-grade ferromanganese, in order that we may not have to use ships for importing the high-grade ores from Brazil.

The usual manufacture in blast-furnaces is wasteful of both fuel and manganese; the furnace must be run hot and slowly, with very hot blast in order to reduce the manganese oxide ore as completely as possible and not waste manganese in the slag. Yet, in spite of all efforts, from 15 to 25 per cent of the manganese going into the furnace escapes reduction and is lost in the slag. This waste of fuel and manganese has led to the use of the electric furnace, in which fuel is required only as a chemical reagent and not to pro-

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Paper read at Fourth Annual Exposition of Chemical Industries.

duce heat, thus saving about two-thirds the fuel requirements of the blast furnace, while the higher temperature available causes the extraction of manganese to reach 90 per cent, i.e., slag losses to be down to 10 per cent or less. Against these economies must be set the considerable expense for electric power and the smaller scale on which the furnaces run. At the present high prices of coke and manganese ore, and in view of the scarcity of manganese and the high price of ferromanganese, the electric ferromanganese industry is able to exist and make large profits. Whether it can do so when normal conditions return, after the war, is questionable; it is to be hoped that it will be able to do so, because of the economy which it undoubtedly possesses in regard to fuel and manganese.

Steel producers use ferromanganese particularly for making the low carbon or soft steels, because they can thus introduce the required manganese for deoxidation without putting in considerable carbon. For higher carbon steels spiegeleisen (15 to 20 per cent manganese), a cheap blast-furnace alloy, can be used, and is being used at present wherever practicable, in order to save ferromanganese. The best practice with either spiegeleisen or ferromanganese is to melt them in a small electric furnace, and tap from it the required weight to be added to the heat of steel. The melted alloy mixes quicker with and reacts more actively upon the melted steel, while less of it is necessary because less is oxidized by the furnace gases. The saving in manganese by the use of the electrically-melted ferro is alone sufficient to justify the expense of melting it in an electric furnace, while better and more homogeneous steel is produced.

Ferrosilicon.

This alloy may run 15 to 90 per cent silicon, but the most commonly used is the 50 per cent grade. It is made from ordinary silica (quartz or sand), reduced by carbon in the presence of iron ore or scrap iron. The blast furnace is able to make only the lowest (15 per cent) grade, because silica is exceptionally difficult to reduce, and under conditions which would reduce 99 per cent of the iron ore in a furnace, or 75 per cent of the manganese ore, only 15 to 20 per cent of the silica present can be reduced, and only a low-grade silicon alloy produced. The higher grades must still be produced in the electric furnace.

The raw materials are ordinary silica, the most abundant metallic oxide on the earth's surface, iron ore or scrap iron (iron or steel turnings or punchings), and coke. Electric furnaces up to 10,000 hp. have been operated on ferrosilicon (50 per cent grade). At the high temperature required, a not inconsiderable proportion of the reduced silicon vaporizes, and burns outside the furnace to a white silica smoke. This can be largely prevented by skillful furnace supervision. In normal times, the 50 per cent alloy sells at $45 to $50 per ton, which is a low price for an alloy so difficult to produce.

Steel producers use ferrosilicon principally for the great activity with which the silicon removes dissolved oxygen from the steel. It is about four times as active as manganese in thus reducing blow-holes and producing sound castings. It is usual, however, to use manganese first, to do the bulk of the deoxidation, and silicon afterwards to finish up the reaction more completely. It is particularly useful in making sound steel castings which are cast into their ultimate form and do not have to be worked into shape, because a slight excess of silicon may make the steel hard to forge or roll, whereas an excess of manganese does not have so bad an effect on the working qualities. A particular kind of steel called silicon steel carries 1 to 2 per cent of silicon and yet forges well; this would be classed as a special steel.

The ferrosilicon industry has attained large proportions in countries where electric power is cheap, particularly therefore in Switzerland, the French Alps, Norway, Canada, and parts of the United States. Under present conditions it is even profitably run where electric power is relatively dear, as at Anniston, Ala., and Baltimore, Md. It is a large, interesting, and rapidly growing industry.

Ferro-Aluminium.

This alloy, with 10 to 20 per cent of aluminium, was made in the electric furnace and used in considerable quantity in steel about 1885-88, but was displaced by pure aluminium as the latter became cheaper. Aluminium is about seven times as powerful as silicon and twenty-eight times as strong as manganese in acting upon the oxygen dissolved in steel; therefore only minute quantities are necessary, say one ounce up to a maximum of one pound of aluminium per ton of steel. Its use gives the finishing touch to the deoxidation of the steel.

About 1885 the Cowles brothers, operating the first large electrical furnaces run in America, at Lockport, New York, made and sold considerable quantities of ferro-aluminium, selling the aluminium in it at the rate of about $2 per pound, while the pure metal was then costing $5. When, a few years later, pure aluminium sold for 50 cents per pound, the steel makers turned to using the pure metal instead of ferro-aluminium, and at the present time aluminium is so used in practically every steel works in the world.

There seems to me a distinct opportunity for makers of ferro-alloys to revive the manufacture and sale of ferro-aluminium. Such great advances have been made in the construction and operation of large electric furnaces since 1890, and so much experience has been had in reducing the difficult oxides to ferro-alloys, that the production of 50 per cent ferro-aluminium at say $100 per ton may be a distinct electric furnace possibility. That would furnish the contained

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aluminium at about 10 cents per pound, as against 30 hs-maynyalolfioeren ,andnrlufr-oeatsn cmfwyp vbgkq cents for the commercial aluminium now used. The alloy should be broken up small before using, and thrown in the runner or on the bottom of the ladle, in order that the melted steel may quickly dissolve it as it runs into the ladle.

Such ferro-aluminium would require bauxite with iron ore or scrap iron, for its manufacture, but there are large deposits of low-grade bauxite rich in iron, in Southern France, which could be reduced directly to the alloy without any additions, and thus furnish very cheap raw material for the operation.

In conclusion, ferro-aluminium is not now being made, but its electric furnace production is a real possibility.

Ferrochromium.

Ferrochromium is used for making what is familiarly but erroneously called "chrome steel." It makes steel exceedingly hard. Very hard cutting tools, and armor plates to resist projectiles, are made of it. Only 2 to 4 per cent of chromium may be used.

Several grades are made in the electric furnace, depending on the per cent of chromium (25 to 75), and the content of carbon (2 to 8 per cent). This alloy takes up carbon so actively in the furnace that it has to be treated subsequently to remove the carbon down to what can be endured by the steel into which it is introduced.

The raw material for its manufacture is cromite, an oxide ore of both chromium and iron. If this is mixed with carbon and smelted in the electric furnace it reduces directly to ferrochromium alloy (often misnamed "ferro-chrome"), and highly saturated with carbon (6 to 10 per cent). Steel makers want lower carbon than this, so the alloy is re-melted with more chromite in another furnace, and the excess of carbon oxidized out. The low-carbon alloy sells for 2 to 3 times the price of the high-carbon crude material.

The cutting off of importations of high-grade chromite ore from Asia Minor has led to intense prospecting in the United States. Fair material has been found in many places, and at present our country is nearly independent of foreign sources of the ore.

Ferrotungsten.

Tungsten (also called wolfram) imparts curious and valuable properties to steel. A small amount (2 to 5 per cent) has been used for half a century or more, to make the steel self-hardening; that is, a tool of this steel need only be let cool in the air, and it becomes hard without the ordinary quenching or chilling operation. Larger proportions (10 to 25 per cent) make a steel which stays hard even when red hot. A tool of this material can be run so fast on a lathe, for instance, that it gets red-hot from the friction and work, yet keeps hard and keeps on cutting. It is called highspeed tool steel, and its use alone has more than doubled the output capacity of the machine shops of the world.

The ore used is either wolframite, a black oxide of iron and tungsten, or scheelite, a white oxide of calcium and tungsten. It is found in considerable quantities in Colorado, and some other Western States, and imports of this ore have not been necessary during the war. In this respect we are much more favorably situated than the European nations. A plentiful supply of tungsten ore may indeed be regarded as a large factor in the production of cannon and fire-arms and all kinds of machinery, and therefore a considerable factor in winning the war.

Ferromolybdenum.

Molybdenum has only recently come into large use in steel. Its action being somewhat similar to that of tungsten, scarcity of the latter metal, particularly in Europe, has led to the manufacture of ferromolybdenum on a comparatively large scale.

The ores are widely distributed but not very plentiful. Molybdenum sulphide, molybdenite, looks almost exactly like shiny graphite but it is a shade lighter in color and nearly twice as heavy. It occurs usually as flakes in granite rock and might easily be mistaken for graphite. Lead molybdate, wulfenite, is a compound of lead and molybdenum oxides, a very prettily crystallized yellow to red mineral in thin square plates. It occurs abundantly in a few lead mines in the West. It is usually first treated to extract its lead, and the residue then worked for molybdenum. The sulphide used to be roasted to molybdenum oxides, and this reduced by carbon in the presence of iron ore or scrap iron in an electric furnace. It is now smelted directly in the electric furnace with carbon and a large excess of lime along with iron ore or scrap iron. Ferro with 50 to 60 per cent of molybdenum is tapped from the furnace like other ferro-alloys, but with molybdenum up to 80 per cent the alloy has such a high melting point that it cannot be tapped out without freezing; it is necessary to make a furnace full of this alloy and then let the furnace cool down and take it apart, taking out a large mass of solidified alloy; the furnace is then rebuilt.

The large use of molybdenum in steel has been so recent that not much has been made public about it. Rumor says that the large German guns which bombarded Liege (the "Black Berthas") were lined with molybdenum steel (6 to 7 per cent) to increase their resistance to erosion. It seems certain that Germany drew considerable supplies of molybdenite from Norway to compensate for shortage of tungsten for high-speed tool steel. Parts of guns, gun carriages, motors, automobiles, have also been made of molybdenum steel of most excellent quality. Canada has been especially active in the manufacture of ferromolybdenum steel, most of which is exported to Europe. This alloy is therefore another valuable war material.

Ferrovanadium.

Without vanadium the modern automobile or autotruck would be a much weaker machine. When steel is desired to withstand the heaviest shocks and vibration, nothing is quite so effective as adding vanadium. This is another comparatively rare metal, found principally in the radium ores of Colorado and as a black sulphide on the highlands of Peru. The canary yellow Colorado ore is treated for radium, and the residues for vanadium and uranium. The U. S. government (Bureau of Mines) operated this process for the radium supply. The black ore of Peru is rich and unusual; it is a sulphide with some asphaltic matter, and it is roasted to the condition of iron-vanadium oxide before reduction. The oxides are best reduced by metallic aluminium. This is the well-known thermit (Goldschmidt) methods of reduction. Electric furnace reduction by carbon is not advantageous because of the large amount of carbon taken up by the alloy; powdered silicon is therefore put into the charge as the reducing agent, together with iron, lime and fluorspar, and then a 30 to 40 per cent vanadium alloy is obtained with seldom over 1 per cent of carbon, a very desirable composition (R. M. Keeney).

Only small amounts of vanadium are necessary to improve steel; 0.1 to 0.4 per cent are the usual quantities. This is fortunate because the vanadium costs $5 per pound and over. Metallurgists suspect that part of the improvement of the steel may be due to the vanadium combining with and removing nitrogen dissolved in melted steel. This is probably true, yet some advantage undoubtedly must be ascribed to the final vanadium content in the steel; both avenues of improvement function. Steels thus treated are unusually resistant to shock and alternate stresses, making them very useful for axles, cranks, piston-rods, and such severe service.

Ferrotitanium.

Titanium is an abundant element in nature. It occurs in immense amounts as a double oxide of titanium and iron, known as ilmenite, or titanic iron ore. This ore can be reduced directly by carbon in electric furnaces to ferrotitanium. The reduction proceeds easier if some aluminium is put in as a reducing agent, but this is expensive and unnecessary. The alloy running 15 to 25 per cent titanium is sold for use in steel as a refining agent to remove oxygen and nitrogen. Thousands of tons of steel for rails has been thus treated, the tests showing considerable improvement in the mechanical properties by the use of quite small amounts (0.10 to 0.20 per cent) of titanium.

Ferroboron.

This is another alloy whose valuable qualities have not yet been entirely determined. Boron is the metallic base of borax, which is a sodiumboron oxide. Borax is very difficult to reduce to the metallic state. Another raw material, not so abundant, is colemanite, containing lime and boron oxide. Many attempts have been made, none very successfully, to reduce this with iron oxide to ferroboron. The American Borax Co. offered a prize, for several years, for a process which would accomplish this. Boron oxide occurs rarely in nature, but it can also be manufactured from borax and colemanite. When the oxide is obtained, this can be combined with iron oxide and the resultant boron-iron compound reduced by carbon in the electric furnace to ferroboron. Small quantities of this alloy have thus been manufactured.

Experiments on steel have shown that ferroboron acts somewhat similarly to ferrovanadium. Experiments in France showed remarkably strong and tough steels were thus made, using 0.5 to 2 per cent of boron. The results have not been properly followed up, partly on account of the difficulty in getting ferroboron; no one, as yet, has taken up its regular manufacture and steel makers can hardly be blamed in these stirring times for not having as yet thoroughly explored its possibilities as an addition to steel.

Ferro-Uranium.

This is the latest of the ferro-alloys to enter the lists. Uranium is a very heavy and chemically, very active element. It is found very scarcely as a black oxide, the mineral pitchblend—the mineral in which radium was first discovered. It is found more abundantly in the Colorado radium ore, a bright yellow oxide and silicate of vanadium, uranium and lime. After extracting the radium and vanadium, the uranium remains in the residue as a by-product, usually as a soda-uranium compound. This is treated so that uranium oxide is obtained, and this can be reduced by carbon in an electric furnace in the presence of iron ore or scrap iron, to ferrouranium (30 to 60 per cent). The recovery of uranium is not high (50 to 70 per cent) the rest being lost in the slag. Mr. R. M. Keeney has recently described these processes in detail, for the first time in the August Bulletin of the American Institute of Mining Engineers.

The results of tests showing the influence of uranium on steel are not yet completely known. Some firms have claimed for it wonderful strengthening power and resistance to shock. The subject is still receiving expert attention from steel makers, and valuable results are confidently expected.

Conclusion.

The ferro-alloys are exceedingly important materials to the steel maker, either in the making of ordinary steel or for producing special alloy steels. They are indispensable to the steel industry. They are important factors in producing both ordinary and fine steels, and therefore in winning the war.

Steel Casting Development in the West

Conditions of Opration on the Pacific Coast With Particular Reference to the Columbia Steel Company—Typical Analyses of Raw Materials and Finished Product.

By J. D. FENSTERMACHER.

Manufacturers of steel castings are confronted with a necessity for three vital things—scrap, sand and experienced mechanics. The question of scrap is being given serious consideration in the far west, not only by steel foundrymen but by the rolling mills which consume more of this material than the foundries. The present demand for scrap exceeds the production. Pig iron is being produced in very small quantities on the Pacific coast and this production is not sufficient to offset the rapidly diminishing quantity of scrap. However steps are being taken to produce suitable pig iron locally on a large scale. This will be the solution of this vital question. California has considerable ore deposits, but coking coal has always been a drawback. Nevertheless, there are favorable indications as to the nearby source for the quantity production of suitable coke, and I hope the time is not far off when the Pacific coast will be producing enough pig iron for its own consumption.

Sand From Illinois.

Next in importance is silica sand. This material is nearly all transported from Illinois. Local sands, including beach sands have been used, but they are not nearly so satisfactory as the natural eastern standards. The transportation of eastern sand is a determining factor in our manufacturing costs. I understand that certain grades of this material have been located in nearby states. This would lessen transportation costs and difficulties somewhat.

Suitably trained mechanics have always been scarce. The importation of this class of labor from the east has not only been expensive but has proved unsatisfactory. The only solution of this problem is for the manufacturers to train their own help. In some places this has been done to a certain extent, but all of the foundrymen on the coast cannot do so.

The absence of stable and multiple work has a great effect on our manufacturing costs. It is very essential, therefore, that the jobbing shop must be provided with mechanics that have a wide experience on all kinds of work, and flask equipment must be varied and flexible. It may also be necessary to use considerable wooden flask equipment according to the nature of the work, and the community in which the shop is located.

The melting stock used at the present time in the basic furnace at the Columbia plant is obtained locally from railroads, mines, smelters, gold dredges, oil fields and shipyards. Scrap brake shoes are considered good material, but are not always obtainable. Clean steel turnings are used in small quantities. The melting is done by oil fuel exclusively. This material is delivered by barges to the company's dock and pumped into storage tanks. Facilities are such that delivery can also be made by tank cars, if emergencies demand. Either steam or air is used for atomizing.

Analysis of Raw Materials.

The magnetite iron ore, limestone, dolomite and calcined magnesite are all secured from nearby sources. The following typical analysis herewith will show the quality of these materials:

	Per Cent
MAGNETITE—	
Silica	4.0
Iron Oxide	90.0
LIMESTONE—	
Silica	0.2
Iron and Alumina	0.2
Calcium Carbonate	99.5
DOLOMITE—	
Silica	0.2
Iron and Alumina	0.3
Calcium Carbonate	55.7
Magnesium Carbonate	43.8
MAGNESITE—	
Silica	6.0
Iron and Alumina	5.0
Lime	1.0
Magnesia	88.0

Magnesite and chrome brick are transported from regular eastern sources. The freight charges on all this material has its influence on operating costs, which causes the foundrymen considerable concern.

In order to convey an intelligent idea of the quality of steel for castings, to meet any recognized specifications, made from the basic all-scrap charged furnace, the following chemical and physical characteristics are given:

Basic Open Hearth Steel Castings Made for Government.

Heat No.	Elastic Limit lbs. per sq. in.	Tensile Strength lbs. per sq. in.	Elongat'n in 2 in.	Reduction of area	Carb.	Sil.	Analysis Sul.	Phos.	Mang.
			Per Cent						
47	35,000	70,000	0.31	0.54	0.26	0.30	0.029	0.015	0.59
58	33,000	64,000	0.32	0.60	0.20	0.36	0.030	0.015	0.55
66	34,500	68,500	0.30	0.56	0.25	0.32	0.038	0.018	0.62
79	33,600	67,200	0.32	0.58	0.25	0.28	0.038	0.019	0.63
93	32,000	62,000	0.35	0.68	0.21	0.34	0.040	0.013	0.68
95	36,000	66,400	0.30	0.60	0.23	0.33	0.039	0.018	0.74
96	32,500	63,000	0.33	0.60	0.23	0.33	0.039	0.018	0.74
100	33,000	66,000	0.31	0.56	0.22	0.34	0.026	0.015	0.57
125	38,500	75,500	0.25	0.50	0.28	0.30	0.040	0.015	0.53
146	33,600	64,800	0.28	0.60	0.24	0.31	0.029	0.014	0.58
150	32,000	60,800	0.35	0.63	0.18	0.32	0.026	0.013	0.62
154	55,000	94,500	0.25	0.54	0.30	0.25	0.028	0.013	0.53*
160	31,000	60,500	0.36	0.64	0.19	0.33	0.031	0.018	0.58

* Nickel, 2.70 per cent.

From paper read before American Foundrymen's Association Milwaukee meeting.

During 1916 increased demands for tonnage were great enough to warrant additional melting facilities. It was decided to install an acid open-hearth furnace. One of medium size was considered necessary in order to produce metal in fair quantities during periods that the basic furnace was shut down for major repairs. These repairs are more frequent for this furnace than the average basic furnace that uses scrap and pig iron. However, in spite of the severe service imposed by melting all scrap an average of 370 heats has been produced. The last run was the best ever made, when 411 heats were turned out before it was necessary to rebuild the furnace.

The acid furnace was built to melt the foundry scrap produced by the basic furnace. Chemical characteristics of this scrap are given in the foregoing table showing material made for castings by the basic furnace. About 90 to 92 per cent of this scrap is used, the balance being made up of standard low-phosphorus pig iron. When the furnace is used for making heats to pour medium and small castings, the heats average about four tons each. This furnace has been operated continuously since last summer, and to date over a thousand heats have been melted. Analysis of the steel made by this process for castings are as follows:

Acid Open-Hearth Steel Casting Made for Government.

Heat No.	Elastic Limit lbs. per sq. in.	Tensile Strength lbs. per sq. in.	Elongat'n in 2 in.	Reduction of area	Carb.	Sil.	Sul.	Phos.	Mang.
					Analysis				
			Per Cent						
560	36,000	70,000	0.31	0.51	0.28	0.30	0.041	0.035	0.57
564	31,500	61,000	0.32	0.56	0.21	0.24	0.043	0.035	0.66
571	31,500	60,500	0.30	0.50	0.20	0.33	0.043	0.039	0.48
582	35,000	69,000	0.29	0.52	0.28	0.28	0.044	0.036	0.61
642	32,000	65,000	0.32	0.51	0.21	0.31	0.034	0.036	0.70
707	36,500	70,500	0.29	0.52	0.28	0.36	0.034	0.027	0.65
710	36,000	68,300	0.27	0.53	0.27	0.27	0.040	0.029	0.57
730	40,000	76,500	0.27	0.46	0.31	0.30	0.034	0.016	0.67
738	32,500	62,000	0.28	0.53	0.21	0.26	0.036	0.033	0.56
741	41,000	78,500	0.26	0.49	0.35	0.29	0.038	0.024	0.73
752	37,000	72,500	0.30	0.57	0.30	0.33	0.044	0.041	0.64
758	50,000	91,000	0.23	0.48	0.43	0.30	0.039	0.040	0.59

All the steel foundries on the Pacific coast are called upon to produce a great variety of castings up to the limit of their melting capacity, but the Columbia Steel Company, being the largest manufacturer west of the Rocky mountains, is called upon to make some very large castings. However, recently this company has had inquiries for castings beyond its present melting capacity. Inasmuch as this situation has developed, the management has authorized the installation of another basic furnace. This will give the Pittsburgh plant three furnaces.

Basic Lining for Electric Furnaces

Preference to Basic Steel Due to Possibility of Conducting Refining Operations on Basic Bottom — Reasons for Rapid Strides of This Method — Description of Basic Furnace.

By F. J. RYAN

The difference commercially between the acid and basic bottom depends entirely upon the product to be produced. In other words, usual average castings, having what is known as the general characteristics of good steel, can be produced on an acid bottom at a very low cost for refractory materials if good scrap is available. If, however, rigid chemical and physical specifications have to be met and miscellaneous scrap only is available, then the basic bottom must be utilized if good steel is to be the result.

Why Acid Bottoms Were Used.

Over 65 per cent of the total output of electric steel in this country previous to our entering the war was on acid bottoms. The reason for this was that electric steel was just beginning to be recognized for its real and true value and also because there was a real scarcity of operators familiar with metallurgical conditions and it was safer to operate the furnace purely as a melting medium.

In the past the usual electric furnace paper has been prefaced with a short review or history of electric furnace development, enumerating the distinctive advantages of electrical apparatus over the existing types of furnace equipment such as the converter, crucible and small open-hearth furnaces.

We have witnessed in the past two years phenomenal strides in electric furnace development from standpoints of both efficiency and number of installations, and the writer, therefore, asks to be excused for presenting nothing except a brief discussion of the types of lining installed in furnace equipment, because it is his opinion that the electric furnace should now be considered as a thoroughly reliable, economical and necessary unit in connection with the average steel plant or foundry installation.

Two of the principal users of electric steel castings, namely the automobile and tractor manufacturers, have in the belief of the writer brought about a revolution in the methods of producing electric steel castings in this country. We have, of course, for some time had the advantage of expert and scientific handling of steel in the electric furnace for the tool steel industry, but the output has not been sufficient to bring about a widespread knowledge of scientific electric steel production. It remained for the auto-

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Paper read before Milwaukee meeting of American Foundrymen's Association.

mobile and tractor industries to accomplish this result.

Designers, especially in the automobile industry, have been attempting to reduce the weights necessary in castings and forgings, and to accomplish this purpose they have necessarily been compelled to create standards which could only be met by basic steel. Therefore on account of necessity, the electric steel manufacturers have been compelled to reorganize their forces and the development of basic operation has been phenomenal even since the last meeting of this association.

The writer has attended the final negotiations for many electric furnace installations and in former days it was customary for the decision relative to the purchase of one or another make of furnace to hinge entirely on whether or not one furnace consumed a few kilowatt-hours less per ton of steel or whether the refractory costs were from 50 cents to $1.75 per ton less. In the past year we have noticed a healthy tendency to keep away from placing too high a value on such figures, for it is child's play to begrudge the small additional costs that are necessary in basic operation if the ultimate product produced is increased in efficiency from 10 to 50 per cent. Take for instance the following problem:

At the present time there is a differential between B and C castings as purchased by the navy department of from 4 cents to 7 cents per pound. Using the lower figure of 4 cents, we have a difference of $80 per ton as a margin on which to carry on the necessary basic operations to secure a result which is very simple on a basic bottom. The extra cost for basic operation would probably not exceed $15, leaving a net total profit to the purchaser of $65, but of more importance is the saving in weight and the use of cheaper raw materials. It will be seen that if a given weight of casting is based upon certain chemical and physical properties and by metallurgical manipulation the same weight of material can be increased in efficiency 20 per cent, the ultimate body weight can then be reduced 20 per cent without injury to the original requirements.

An Eye to the Future.

In the plant of one of the largest automobile manufacturers in the world there has recently been installed a small electric furnace solely for the testing and establishment of classifications of different types of steels for after-the-war consumption. The managers of this plant have secured the best technical knowledge available and their sole and one purpose is to develop the highest practicable grade of steel that it is possible to produce. Close records of all of the results are being kept and the producer in the future faces the problem of meeting such specifications if he expects to obtain any tonnage.

This is one of the many instances that have come up especially during the past year. In fact, the question of working to specifications and having the ultimate produce subject to inspection has become second nature to us on account of the many government contracts which are spread about all over the country. Many of us have probably not had time to consider what this will mean in the future, but we probably will be willing to admit that there is little likelihood that we will ever return to the hit-and-miss method that was quite general in the past. Recollect for instance the many large and supposedly up-to-date plants that were producing electric steel entirely by the fracture observation method. In some instances the question of carbon was handled by the supermelting of the electrode for a certain number of moments in the molten bath and the question of deoxidation was looked upon as one of the necessary evils to be talked about and then forgotten.

Furnace Must Be Properly Designed.

Every electric furnace design is not suitable for basic operation. The ideal furnace is one which exposes the largest possible surface of the metal to the action of the slag without being subject to freezing conditions at any part of the furnace. Where the arc or arcs are centralized in the center of the furnace it is necessary to cut down the surface exposed to the slag, thereby deepening the bath. This deepening of the bath in the average furnace has a tendency to cause segregation on account of the heavier alloys which are used, such as tungsten and chrome.

The ideal condition in the application of heat is, of course, the supplying of correct proportions above and below the bath. Many methods and designs have originated from inventors attempting to secure this ideal condition, but it was not until about a little over a year ago that any definite or practical results were secured. There are now on the market here and abroad furnaces operating what might be termed as an arc resistive design and exceptional results are being obtained. It is claimed that the heat which is supplied by and in this type of furnace and the resistive action of the current passing through the hearth starts a definite convection action which very slowly stirs the molten charge doing away with segregation and causing thorough deoxidation.

In the purely top arc types of furnaces, high-grade steels are being made daily, but in such operation close attention must be given to secure a uniform product. If the heat is not distributed uniformly through the bath, segregation will be the result and if too much heat is applied, contamination of the steel by the slag is possible. Difficult as these problems may seem to the man that is now operating on an acid bottom, they can all be overcome by the use of skilled labor or by training the available staff, and the ultimate proportion of profit will be greater, also an improved reputation for the product will place the production always in demand and the percentage of returns in poor material will be cut down to a minimum.

Scrap Will Become Scarcer.

As the number of installations of electric furnaces increases, so will the available proportion of scrap decrease and with the depreciating available supply there will be a decrease in the available stock of what we might term as No. 1 low-phosphorus material and it is upon this No. 1 material that the acid operating furnaces are entirely dependent.

The government has already placed a differential on scrap that is nearly sufficient to overcome the additional cost of basic melting without even considering the additional return for the product and the cutting down of the material utilized by the increase of efficiency. In the opinion of the writer the question between basic and acid operation is purely a question of a commercial profit and loss with the advantage on the side of the basic lined furnace.

The history of every known product teaches the lesson of increase and not decrease of efficiency, and with the acid-lined furnace limited solely to one procedure of melting, it must in the course of events gradually be done away with in the electric furnace industry and be replaced by the more efficient and economical method of basic operation.

The writer realizes that the arguments brought forth in this paper nearly all pertain to the commercial aspect of the problem. He has purposely kept away from technical discussions pertaining to the actual handling of the basic and acid bottoms for the reason that we are thoroughly aware that there is now available in this country sufficient technical skill and labor to make either possible.

Every industry is entirely dependent upon the profit accruing from the sale of its product and in view of the future we must face after the war, the commercial aspect is the really important and vital side of the question that should now be considered. If this is correct, we must prepare to rearrange our plant procedure so that it may be based upon the most efficient and economical methods, but do not let it be only economical.

Producing Armg Ordnance Steel Casting

Discussion of Low Carbon and High Manganese, and High Carbon and Normal Manganese Specifications—Typical Analysis of Steels Presented—Control of Analysis and Suitable Annealing.

By CAPT. E. R. SWANSON.

You gentlemen are familiar with the fact that requirements as to physical properties for the three principal grades of steel castings for the ordnance department are now the same as those of the American Society for Testing Materials. The chemical properties also are identical with the American Society for Testing Material specifications, except that greater latitude is given in the case of sulphur. For reference the figures are given as follows:

Cast Steel	Elastic limit per sq. inch	Tensile strength per sq. inch	Elongation per cent in 2 inches	Reduction of area per cent
No. 1......	27,000	60,000	22	30
No. 2......	31,500	70,000	18	25
No. 3......	36,000	80,000	15	20

The time at the writer's disposal does not permit the extended detailed observation for presentation that the subject merits, and in fairness to the foundrymen, much matter available could not be published and accredited.

Practically all steel castings for ordnance purposes are made by the acid open-hearth, electric furnace or side-blow converter.

The problem of meeting requirements has resulted in the establishment of two methods. One makes use of combinations of low carbon and high manganese; the other, high carbon and normal manganese. The first method is of especial value to the converter shop.

The chemical analysis followed by a shop getting 98 to 100 per cent acceptances on first test for the No. 2 steel, using the converter, is as follows: Carbon, 0.26 to 0.30 per cent; manganese, 0.65 to 0.75 per cent; silicon, 0.26 to 0.35 per cent; sulphur, 0.07 per cent, and phosphorus, 0.05 per cent.

This steel is annealed by heating to 1650 degrees F., soaking four hours at that temperature and cooling slowly in the furnace. This shop is not making any of the No. 3 grade steel.

One shop is working on orders various items of which call for No. 1, No. 2 and No. 3 grades. Their practice is to fill them all with steel of the No. 3 grade, using the converter process. Their chemical analysis is as follows: Carbon, 0.38 to 0.45 per cent; manganese, 0.75 to 0.85 per cent; silicon, 0.40 to 0.50 per cent; sulphur, 0.04 per cent, and phosphorus, 0.05 per cent.

This steel is annealed by heating to 1575 degrees F.,

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soaking four hours at that temperature and cooling slowly to 700 degrees F. in furnace, at which temperature castings are pulled out into the air. This practice results in 95 per cent acceptances on first test.

Another Analysis.

Another company using converters for the No. 3 grade, works to the following analysis: Carbon, 0.25 to 0.30 per cent; manganese, 0.90 to 1.00 per cent; silicon, 0.30 to 0.35 per cent; sulphur, 0.07 per cent; and phosphorus, 0.05 per cent.

This steel is annealed by heating to 1700 degrees F., soaking four to six hours at that temperature and cooling in air. It is then drawn by heating to a temperature of 900 to 1100 degrees F., depending on the carbon, and cooling slowly in furnace. This firm deals with the No. 2 grade steel in much the same manner except that the carbon in this case ranges between 0.24 and 0.28 per cent, with manganese between 0.85 and 0.90 per cent. The castings are annealed at 1750 degrees F. with subsequent draw.

A most successful company using the electric furnace for the No. 3 grade, works to a chemical analysis as follows: Carbon, 0.25 to 0.30 per cent; manganese, 1.10 to 1.30 per cent; silicon, 0.35 to 0.45 per cent; sulphur, 0.05 per cent, and phosphorus, 0.04 per cent.

Castings are annealed by heating to 1,650 degrees F. and soaking three to four hours at that temperature, cooling in the air, and then drawing at from 900 to 1,100 degrees F., cooling slowly in furnace.

Electric Furnace Analysis.

Another company successfully meets the requirements for both No. 2 and No. 3 grades of steel by making only one grade, namely the No. 3, using the electric furnace. Their average analysis is as follows: Carbon, 0.38 to 0.42 per cent; manganese, 0.60 to 0.70 per cent; silicon, 0.25 to 0.35 per cent; sulphur, 0.05 per cent and phosphorus, 0.04 per cent.

They anneal this steel by heating to 1,650 degrees F., soaking at that temperature for six hours, and cooling the castings slowly in the furnace four to six hours.

The chemical analysis followed by a company using the acid open-hearth which has had 100 per cent acceptance is as follows: Carbon, 0.42 to 0.48 per cent; manganese, 0.65 to 0.70 per cent; silicon, 0.25 to 0.30 per cent; sulphur, 0.04 per cent; and phosphorus, 0.05 per cent.

Their practice is to allow three hours heating, two hours soaking at 1,650 degrees F., and five to eight hours cooling in furnace.

A resume of the foregoing shows the manner in which requirements are being met by companies having from 95 to 100 per cent acceptances on the first test. The high percentage of acceptances show that specifications are not excessive.

A very elaborate treatise could be drawn up on the subject of critical temperatures, length of annealing periods, etc. The critical point will vary according to the chemical analysis. You all know that to secure proper refinement of structure all parts of castings must be heated above the critical point and held long enough to permit necessary refinement. This period will vary according to the thickness of section.

Specifications Can Be Met.

Disclaiming any desire to criticise equipment or methods in shops having difficulties, it is desired to make this point—that No. 2 and No. 3 grades are being made successfully and commercially. In order to do this, two things are required: First, control of analysis of product, so that the castings will analyze within predetermined limits; and second, annealing equipment of such nature that the furnace can be brought up to the desired temperature at a predetermined rate with equal temperatures prevailing in all parts of furnaces at the same time.

Control of analysis is had by competent supervision assisted by suitable chemical laboratory equipment.

Control of heat treatment can be exercised by the use of properly designed furnaces, so constructed that uniform heating prevails together with proper circulation; and the installation of proper recording pyrometers equipped with sufficient thermocouples so that furnaces can be checked for cold spots.

The absolute fundamental in meeting the requirements of the No. 2 and No. 3 grades is proper chemical analysis, supplemented by accurate annealing or heat treatment.

An extreme illustration of what has been done in the past, in a shop not equipped to anneal small castings, follows: The practice was to wait until a heat was poured which left a heavy skull in the ladle. The castings were annealed (?) by throwing them in the ladle and leaving them until the skull was cold. It is to be expected that they would experience trouble.

Weaknesses Are Remedied.

Most of the wideawake steel foundries have by this time discovered their weaknesses and have remedied them by installation of suitable up-to-date equipment.

Occasionally a heat is discovered that does not respond to proper heat treatment even though analysis is normal. An examination with the microscope will usually show the difficulty. Many companies are using the microscope as a daily check on their product. This is a refinement of practice that up to a short time ago prevailed in but very few foundries, but one of the many good things coming out of this world war is an improvement in the quality of steel castings that is really remarkable and of which the steel casting people can really be proud.

The Cottrell Process for Potash Recovery

Conditions of Operation on the Pacific Coast With Particular
The United States Has Sufficient Furnace Capacity to Produce Annually Over 1,500,000 Tons of Potash Per Year.

By LINN BRADLEY.

The subject of potash recovery is becoming of more universal interest to the public as well as to the technical man. The daily press and the magazines frequently refer to what is being done and to what should be done in this country in order to offset and decisively defeat the Kaiser and his followers. Recently several news items and editorials have appeared in the metropolitan press calling our attention to what is being accomplished in England toward making their country independent of Germany, and it appears that the British government has furnished large sums of money to assist in recovering potash from their iron blast furnace gases. It is predicted that this source will enable England to obtain enough potash to equal her entire pre-war importation from Germany. France is reported to be as keenly awake to the possibilities along this line and we may see the time when France will be recovering large quantities of potash from iron ores which Germany has made such strenuous efforts to control. However, it is not surprising that interest in potash should increase, when we consider that this is the one big economic weapon which Germany has relied upon to regain her place in the sun after the war. She boasts that all countries will have to depend on her for potash. She claims that other countries cannot produce potash to compete with that supplied by Germany. But in this as in many other instances her reasoning is based on lack of information as to facts and possibilities.

The recovery of potash in this country is making rapid strides. The industry may be roughly divided into those plants in which the recovered potash is the main product and those in which the potash is recovered as a by-product. In this paper the latter phase will be considered as it is believed that while the largest immediate tonnage may be obtained from desert lakes, kelp, alunite and a few other sources, nevertheless a study of the economic problems will show that the surest way of making our potash industry a permanent and enduring one, able to supply all of our requirements even against German competition, is to develop and rely upon the by-product potash.

Investigation Made on Blast Furnace Dust.

Early in 1912 the Research Corporation of New York started to develop the Cottrell processes and apply them to various plants in the eastern portion of the United States. Shortly after work had been begun, a paper was read and a demonstration given at a meeting of the local section of the American Chemical Society near Allentown, N. J. The next day arrangements were made for a visit to the South Bethlehem plant of the Bethlehem Steel Company. An investigation was undertaken by Mr. R. J. Wysor and this resulted in extensive investigations thereafter to determine the possibility of cleaning these gases by the Cottrell processes and recovering whatever of value could be obtained from the collected material. Mr. Wysor has published a very able and valuable article in the Transactions of the American Institute of Mining Engineers (1917) giving a great deal of data on ores, fluxes, slags, potash balances and other items directly related to the recovery of potash as a by-product of blast furnaces. His paper probably served as an inspiration for much of the work which has been undertaken abroad.

Analyses of iron ores, cokes, limestones and dolomites show a wide variation in potash content, and it is therefore advisable for one interested to make sure that his raw materials are sufficiently rich to warrant a potash recovery plant. Furnaces which produce a large tonnage of slag per ton of iron on account of the iron content of the furnace charge will, of course, carry more potash into the slag than furnaces which produce a relatively small volume of slag, other things being equal except for composition of the charge. Some iron ores carry as high as 60 per cent of iron and are practically devoid of potash. Some cokes have a low ash and are low in potash. Some limestones and some dolomites may be quite pure. If, therefore, the ores are uniform and properly prepared and the fuel and flux are properly proportioned, the slag volume will be small and the potash in the gases may likewise be negligible. On the other hand, if the iron ore carries as much as two or even one per cent of potash (K_2O) and the coke ratio is high and it and the flux contain as much as .25 to .50 per cent of potash, quite a large quantity of potash will be volatilized and carried off by the gases from which it can be recovered. The high temperature in the blast furnace and the length of time under treatment allows the silicates to be decomposed more readily than in a cement kiln where the temperatures are not so high. The potentialities of the by-product recovery from blast furnaces

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From paper read at the Fourth National Exposition of Chemical Industries.

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would, therefore, seem to surpass the possibilities of the Portland Cement Industry in this regard.

Numerous attempts have heretofore been made to recover potash from silicate rocks. The investment and operating cost, especially for fuel, are hard to overcome if one endeavors to volatilize the potash and recover it and nothing else. It therefore seems that the best way to recover the potash from these silicates by heat treatment is to charge these silicates into existing furnaces along with the regular charge and recover the potash as a by-product thus eliminating the investment and operating cost for new and separate furnaces. This would be profitable up to a certain point, beyond which this practice would, however, not be desirable.

Since the investigations referred to were begun at South Bethlehem, numerous other furnaces have been investigated and potash balance made. Iron ores have been found in abundance in Alabama which carry from one to as high as three per cent in potash and carry enough iron to make them highly suitable for this purpose. The following tables show the results of one investigation.

Percentage Analysis of Materials.

Material	Fe	SiO_2	Al_2O_3	CaO	MgO	Ash	Car'n.	Na_2O	K_2O
Ore No. 1	46.36	17.42	4.19	5.03	8.33	....	....	0.62	1.27
Ore No. 2	54.69	12.78	3.49	4.04	6.00	....	....	0.39	0.74
Stone ...	....	1.56	0.58	46.24	7.25	....	....	0.64	0.26
Coke	....	5.82	3.49	0.51	0.24	13.01	86.15	0.39	0.32

Charged Into Blast Furnace.

Materials	Lb. per Ton Iron	Total Lb. K_2O	Per Cent. of Total
Ore No. 1	3,115	39.56	61.0
Ore No. 2	1,168	8.65	13.2
Stone	1,440	3.74	5.8
Coke	4,050	12.97	20.0
Total	9,773	64.92	100.0

Summary.

Total K_2O charged into furnace per ton of iron produced, lb	64.92
Lost in slag per ton of iron produced, lb	11.60
Lost as fume from gas leaks per ton of iron produced estim.), lb	1.16
Total potash recoverable from gases per ton of iron produced, lb.	52.16
Total potash in dust in gases as per analysis, per cent	34.11
Water soluble potash in dust in gases as per analysis, per cent.	32.10
Portion of total potash in dust, which is water soluble per cent	94.11
Total water soluble potash recoverable per ton of iron by collecting the dust in the flue gases, lb	49.09
Total water soluble potash as above per 500 tons iron per day, lb.	24545.00
Total water soluble potash as above per year of 350 days, tons	4295.37
Portion of total potash charged into furnace which is recoverable from gases in water soluble condition, per cent	75.62
Safe estimate of above amount recoverable in operating practice, per cent	80.00
Safe estimate of above amount recoverable as above per year of 350 days, tons	3436.29

A study of the above figures will show that it is desirable to keep the potash content of the raw materials up to the highest point and to keep the slag volume and potash content as low as possible It is clear that if the slag volume remained constant as well as its analysis that if only 11.6 pounds of potash had been contained in the furnace charge there would have been nothing available for collection. With suitable slag volume and potash content and a rich potash charge, the recovery of potash in quantities worth while is readily obtained. Sodium chloride has been found helpful in liberating the potash in such way that it is recoverable in the dust in a water soluble form. While working at a cupola furnace in which sash weights were made from old tin cans and other metal waste, it was found that the use of common salt, sodium chloride, greatly increased the fume volume and density and this later was shown to be due to the fact that chlorides of lead, tin and zinc were formed and readily volatilized as such. The use of salt has been extended to cement kiln practice and to other uses in connection with the recovery of silver, lead and zinc from low grade ores and tailings, the values being recovered from the gases after volatilization as chlorides.

Consideration of data such as presented in the tables given below resulted in an effort being made to find raw materials suitable for making iron and yet carrying high percentages of potash. Samples of ores, fluxes and cokes were obtained from a number of furnaces and other sources, and later on this work was carried on much more extensively by the Bureau of Soils of the Department of Agriculture. It is probable that Mr. Frederick Brown of that bureau has now collected data on nearly all of the raw materials available for iron making and that if such data were made public in the near future, it would be of great assistance in connection with the problems under consideration. Personal efforts to find materials such as described developed the fact that in the eastern part of Alabama there is a very large tonnage of iron ores carrying in some cases an average of one per cent of potash and in other instances an average of about 1.80 per cent of K_2O, several analysis showing a content of over 3 per cent K_2O. I am indebted to Dr. J. S. Grasty for having brought these ores to my attention and for much of the data on their iron and potash content as given later in this paper. Mr. M. W. Bush, president Shelby Iron Company has also contributed data on the iron situation of the South and the values of these iron ores in furnace operations. I have examined these properties and have interviewed blast furnace operators who have used them in their furnaces and hold the opinion that they constitute an asset of importance to the nation as well as to interested parties. They should receive the consideration of the government in connection with our war problems and likewise our post-war problems so as to assist in rendering our country absolutely independent of Germany. The ores carry an average of from 48 to 52 per cent of iron, are very uniform, easily mined and shipped as they are directly on the railroad, and operate satisfactorily in the furnace producing good iron at low cost. Their potash content also acts as a desulphurizer, thus improving the grade of iron. The phosphorus content is very low.

The following table has been compiled to show the economic importance of these ores as a source of potash, the figures having been used on experience at several other furnaces as well as on the data obtained in connection with these particular ores and at various iron furnaces in the South. The tables has been submitted to experienced iron blast furnace operators for suggestions and criticisms. For comparison, other ores have been included in the table. The composition of the high-potash iron ore has been taken from the average of over one thousand tons of such ore shipped to furnaces on which K_2O was determined for each car of this particular shipment.

Percentage Contents.

	Coke	Stone	Gray No. 1	Red No. 2	Brown No. 3
Silica SiO_2	8.70	2.00	19.2	15.0	19.5
Alumina Al_2O_3	5.00	1.00	4.8	4.0	3.8
Lime CaO	0.30	53.00	1.3	17.0	6.0
Potash K_2O	0.30	0.30	1.8	0.2	0.2
Iron Fe	1.70	0.00	49.8	36.0	42.0
Ore required for one ton iron, lb			4398	6039	5212
Percentage of burden			46.07	54.35	46.87
Coke required for one ton iron, lb			2700	3900	3000
Percentage of burden			28.29	35.22	26.98
Stone required for one ton iron, lb			2448	1159	2909
Percentage of burden			25.64	10.43	25.15
Total potash content of burden per ton iron, lb			99.5	29.57	33.97
Deduct for losses in slag and elsewhere			10.4	15.6	14.0
Total potash collectable for gases, lb			89.1	13.97	19.97
Slag volume per ton iron, lb			2715	3290	3090
Total potash in gases per day (500 tons iron)			44550	6985	9985
Total potash in gases per 350 day years, tons			7796	1222	1747
Assume eighty per cent recovery, this equals			6237	978	1406
Value per annum at $500 per ton of K_2O			$3118500	489000	703000
Value per annum at $100 per ton of K_2O			623700	97800	140600

The total production of pig iron in this country is such that about 200 furnaces of such size as referred to above would be required to meet our requirements if the furnaces were of the same capacity. So it is easy to see that we now have sufficient furnace capacity to produce annually over 1,500,000 tons of potash per annum, far in excess of our pre-war requirements. The difficulty lies in the fact that we have not found that all furnace burdens carry the amount of potash shown under the No. 1 column. If the furnace charges and operations could be adapted so that one-fifth of the amount, or 300,000 tons, could be produced this would meet our needs without assistance from any other source. The three constituents of the charge, ore, stone and coke, contain more or less potash. By using those raw materials which carry more than usual amounts of potash, our recoveries can be considerably augmented. In cases where ores are smelted which are excessively limey, feldspar, potash bearing slate or other potash bearing silicates could be fed into the furnace and thus increase the potash content of the furnace burden.

By-Product Potash From Feldspar Cement

Mr. H. E. Brown, a chemical engineer of New York City has developed a process for making a special cement from the slag obtained from a blast furnace and at the same time recovering water soluble potash from the gases. He charges limestone, coke and feldspar into the furnace. Now if iron ores of suitable kind could be used for a portion of the raw material, it might be possible to produce potash from the gases, also pig iron, and a slag which could be readily converted into a marketable cement.

Potash Prospects in the Iron Industry.

Referring again to the iron industry and its relation to the potash question, it should be pointed out that in the Alabama district there is an abundance of excellent coal, labor is plentiful and cheap, and the climatic conditions are such that the district may be considered an all year one as far as operating is concerned. Then, when it is realized that there is immediately at hand an enormous tonnage of high grade iron ore which carries such a large potash content and that the South produces our cotton and therefore is the large consumer of potash and thus provides a large market within a few miles, the economic importance of this situation can be better appreciated. Other iron ores contain potash, some of which may justify recovery plants, and we should be on the lookout for such materials, keeping in mind that our goal is to obtain our potash as a by-product at such a cost as will enable us to ignore Germany forever and thus make the dreams of the American chemist and engineer come true.

The South produces pig iron cheaper than any other district in normal times. In fact their furnaces must do this in order to stay in the market. The South does not yet consume as much iron and steel products as its population justifies and therefore their iron must carry a high freight charge if it is shipped North to the larger markets. The manufacture of cast iron pipe has, however, grown to a large industry. In the future more and more iron and steel will be consumed locally as it is evident that the South is coming into its own very rapidly. The additional profit which can be obtained from the potash will be of great assistance in keeping their iron furnaces in blast when the market sags. The South has a very fortunate combination of labor, raw materials, climate and a large and near fertilizer market. In France and in Great Britain the governments have taken an active interest in the possibilities along the lines herein pointed out. It has been reported that investigations extending over a period of three years have shown that Great Britain can produce enough potash to satisfy all her requirements.

Waste Heat From Open Hearth Furnaces

Utilizing Waste Heat from Open Hearth Furnaces for the Generation of Steam—Complete Description of Test With Results Including Heat Balance Sheets—Effect on Operation of Furnace.

By THOMAS B. MACKENZIE.

PART I.

About twenty years ago the firm with which the author is connected was engaged in laying down a new smelting shop with acid-lined open-hearth furnaces of a nominal capacity of 60 tons, and it was decided to put boilers between them and the chimneys, with the intention of generating enough steam to blow the gas producers. The boilers selected were of the Cornish type, 30 ft. long by 7 ft. diameter, with a single internal flue 42 in. in diameter. The waste gas from the furnace was divided into three streams, each of which traveled once along the length of the boiler, reuniting again at the chimney end. These boilers were duly erected and tried, but owing to the cooling effect on the gases the draft of the furnaces was reduced to such an extent that their operation was slowed down sufficiently to compel this attempt to recover the waste heat to be abandoned. The boilers were accordingly removed, re-erected in ordinary settings, and fired by hand in the usual way.

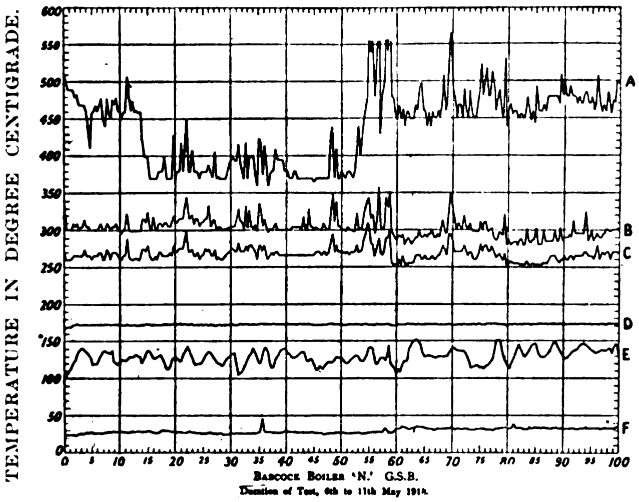

Fig. 1.

A—Temperature of gas entering boiler.
B—Temperature of gas entering economizer.
C—Temperature of gas leaving economizer.
D—Temperature of steam in boiler.
E—Temperature of feed water entering boiler.
F—Temperature of feed water entering economizer.

Although this method of utilizing the waste heat from the furnaces had proved abortive the author was not convinced that the problem could not be solved and after giving the subject some thought it occurred to him that the placing of an induced draft fan beyond the boiler would be a solution. In order to put his ideas on record he prepared a Paper on the subject, which was read before the Institution of Engineers and Shipbuilders in Scotland* on March 21, 1911, the title of the Paper being "On Means for Economizing Fuel and Utilizing Waste Heat in Malleable Iron and Steel Works." As a direct result of the Paper the author was given permission to have an experimental boiler, economizer, and fan, on the lines he had advocated, attached to one of the smaller furnaces in the works to test the predictions made.

The furnace selected for the experiment was an acid-lined open-hearth furnace of ordinary construction and of 30 tons nominal capacity. The boiler selected was of the Babcock & Wilcox water-tube type, having a heating surface of 1,619 sq. ft. In series with the boiler was placed a Green's economizer, having a heating surface of 720 sq. ft. The fan adopted was of the Keith-&-Blackman type, having an impeller 20 in. diameter driven by a variable-speed direct-current motor of 20 b.h.p. As originally erected, two openings were made in the steel chimney attached to the furnace—a lower one to admit the waste gases to the boiler, and a higher one for their return after passing over the heating surfaces of boiler and economizer, a cast-iron damper of the butterfly type being fitted in the chimney between the openings. This arrangement did not work satisfactorily, as the damper could not be kept tight. A plate damper was then fitted at the top of the chimney, the upper opening closed, and the fan arranged to discharge direct into the air. After some other minor troubles had been overcome the installation was got to work satisfactorily, and a test was made extending over a period of 111¼ hours, in order that a fair average from all conditions of the furnace would be arrived at. (See Fig. 1.)* The mean values of the observed data are as in Table I.:—

Table I.

Temperature of "products" entering boiler, 504° C.
Temperature of "products" leaving boiler and entering economizer, 254° C.
Temperature of "products" leaving economizer and entering fan, 169° C.
Temperature of cold feed entering economizer, 11.6° C.
Hemperature of hot feed leaving economizer and entering boiler, 117.8° C.
Steam pressure per square inch (gauge), 86.5 lbs.
Dryness factor (assumed), 0.95.
Weight of water evaporated per hour, actual, 2,440 lbs.

From paper read before autumn meeting of British Iron and Steel Institute.

Weight of water evaporated per hour, "from and at," 2,800 lbs.

Weight of water evaporated "from and at" per square foot of boiler heating surface, 1.73 lbs.

Natural draft of chimney with boiler, etc., dampered off, 0.6 inch W.G.

Draft at base of chimney with boiler, etc., on and fan running, 0.8 inch W.G.

Probable volume of "products" at s.t.p. passing through boiler, economizer and fan per hour, 380,000 cub. ft.

From these data the heat balance-sheets in Table II. were calculated:—

Table II.

Boiler.

Heat received per hour:—	Lb. calories	Per cent.
In 1,081,000 ft.^{3} "products" at 504° C...	4,086,000	93.37
In 2,440 lbs. hot feed at 117.8° C......	289,700	6.63
Total	4,375,700	100.00
Heat expended per hour:—		
In evaporating 2,440 lbs. hot feed to steam at 101 lbs. per sq. in. abs. and dryness factor 0.95	1,555,000	35.55
In 733,500 ft.^{3} "products" delivered to economizer at 254° C.................	1,972,000	45.06
Other losses (by difference)..........	848,700	19.39
Total	4,375,700	100.00

Economizer.

Heat received per hour:—		
In 733,500 ft^3 "products" at 254° C.....	1,972,000	98.58
In 2,440 lbs. coal feed at 11.6° C......	28,310	1.42
Total	2,000,310	100.00
Heat expended per hour:—		
In heating 2,440 lbs. cold feed to 117.8° C.	289,710	14.48
In 615,200 ft.^{3} "products" discharged at 169° C..............................	1,292,000	64.60
Other losses (by difference)..........	418,610	20.92
Total	2,000,310	100.00

Efficiencies.

$$\text{Boiler} = \frac{1{,}555{,}000 \times 100}{4{,}375{,}000} = 35.55 \text{ per cent}$$

$$\text{Economizer} = \frac{289{,}700 \times 100}{2{,}000{,}310} = 14.48 \text{ per cent}$$

$$\text{Over all} = \frac{1{,}555{,}000 \times 100}{4{,}114{,}310} = 37.80 \text{ per cent}$$

The fan absorbed 14.3 Board of Trade Units of electricity per hour.

During the trials the furnace was working at the rate of 2.25 tons of ingots per hour. The amount of steam generated was therefore

$$\frac{2{,}440 \text{ lbs. per hour}}{2.25 \text{ tons per hour}} = 1{,}084 \text{ lbs. per ton of ingots.}$$

If the steam generated per hour had been used in a modern turbine with a good vacuum to generate electric energy the amount generated would have been:—

	158.0 B. T. Units.
Deduct amount used by fan..........	14.3 B. T. Units.
Leaving a net amount of energy available for outside work of............	143.7 B. T. Units.

Assuming boiler fuel to have a calorific value of 6,700 lbs. calories per pound, and that ordinary steelwork boilers have an efficiency of 65 per cent, the fuel equivalent of the steam generated was 357 lbs. per hour, equal to 158.7 lbs. per ton of ingots. If we divide the net amount of electric energy available for outside work by the rate of production of ingots, we obtain 63.86 Board of Trade Units per ton, an amount which should be sufficient to roll the steel produced by the furnace. These results having demonstrated that the author's arrangement was quite practicable and did not in any way interfere with the furnace output, it was decided to provide a new smelting shop in process of erection and containing open-hearth furnaces of 45 tons nominal capacity with similar equipment.

The equipment consists, for each furnace, of a Babcock and Wilcox water-tube boiler having a heating surface of 1,827 sq. ft., a Greens' economizer having a heating surface of 960 sq. ft., and a Keith-&-Blackman fan with an impeller 30 in. diameter, driven by a variable-speed direct-current motor of 40 b.h.p. The fans discharge through short funnels direct into the atmosphere. The furnace chimneys have disc-plate dampers at the top, which are kept nearly closed when the boilers, economizers, and fans are in operation. There are two reasons why the dampers are not closed fully, one being that the boilers and fans are rather small, and the other being a fear lest an explosive mixture would become pocketed in the chimney at each reversal of the furnace with the risk of "kicks" taking place which might cause damage to the plant.

This plant was finished and put to work shortly before the war broke out, so that no tests were made of their performance. Since the war began the author has been jointly responsible for adding seven boilers and fans to old furnaces and ten to new furnaces, and it is unfortunate that the theory was not developed, as, had it been done, larger boilers would have been used and more steam obtained. A number of tests have now been run, details of which are given in Table III. The duration of test was 99 hours, the readings being taken at 20-minute intervals.

Table III.

I.—Waste heat Boiler on O.H. Furnace of 45 Tons Nominal Capacity.

Temperature of "products" entering boiler, 585.3° C.
Temperature of "products" entering economizer, 273° C.
Temperature of "products" entering fan, 181.6° C.
Temperature of feed entering economizer, 6.95° C.
Temperature of feed entering boiler, 120.6° C.
Steam pressure per sq. in abs., 119 lbs.
Dryness factor of steam (assumed), 0.95.
Total water evaporated, 393,251 lbs.
Water evaporated per hour, 3,972 lbs.
Water evaporated per hour "from and at", 4,604 lbs.
Evaporation "from and at" per sq. ft. H. S., 2.52 lbs.
Electric energy used by fan (kw. hours), 26.40.
Equivalent to (brake-horse-power), 31.85.
Draft entering boiler, 0.91 inch W.G.
Draft between boiler and economizer, 2.43 inch W.G.
Drawt entering fan, 3.43 inch W.G.
Probable volume of "products" at s.t.p. passing through boiler, economizer and fan per hour, 400,000 cub. ft.
Heat contents of "products" entering boiler at 585.3° C. in lb. calories per cubic ft. s.t.p., 12.56.
Heat contents of "products" entering economizer at 273°

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C. in lb. calories per cubic ft. s.t.p., 5.59.

Heat contents of "products" entering fan at 181.6° C. in lb. calories per cubic feet s.t.p., 3.66.

From these data the heat balance-sheets in Table IV. have been calculated:—

Table IV.

Boiler.

Heat received per hour:—	Lb. calories	Per cent
In 1,258,000 ft.^{3} "products" at 585.3° C..	5,060,000	91.32
In 3,972 lbs. hot feed at 120.6° C........	481,400	8.68
Total	5,541,400	100.00
Heat expended per hour:—		
In evaporating 3,972 lbs. hot feed to steam at 119 lbs. per sq. in abs. and dryness factor 0.95....................	2,540,000	45.83
In 800,000 ft.^{3} "products" delivered to economizer at 273° C..................	2,237,200	40.38
Other losses (by difference)..........	764,200	13.79
Total	5,541,400	100.00

Economizer.

Heat received per hour:—		
In 800,000 ft.^{3} "products" at 273° C.....	2,237,200	98.77
In 3,972 lbs. cold feed at 6.95° C........	27,800	1.23
Total	2,265,000	100.00
Heat expended per hour:—		
In heating 3,972 lbs. cold feed at 120.6° C.	481,400	21.25
In 666,200 ft^3 "products" discharged at 181.6° C.	1,464,400	64.66
Other losses (by difference)...........	319,200	14.09
Total	2,265,000	100.00

Efficiencies.

$$\text{Boiler} = \frac{2{,}540{,}000 \times 100}{5{,}541{,}400} = 45.83 \text{ per cent}$$

$$\text{Economizer} = \frac{481{,}400 \times 100}{2{,}265{,}000} = 21.25 \text{ per cent}$$

$$\text{Over all} = \frac{2{,}540{,}000 \times 100}{5{,}087{,}800} = 49.91 \text{ per cent}$$

Theoretical power required to move 666,200 cub. ft. of "products" per hour at a temperature of 181.6 deg. C., with a suction of 3.43 in. water-gauge, is equal to 6 b.h.p. The efficiency of the fan is therefore:—

$$\frac{\text{Theoretical horse-power} = 6.0}{\text{Actual horse-power taken} = 31.85} = 18.84 \text{ per cent}$$

During the test the furnace was working at the rate of 4.18 tons of ingots per hour. The amount of steam generated was therefore:—

$$\frac{3{,}972 \text{ lbs. per hour}}{4.18 \text{ tons per hour}} = 949.3 \text{ lbs. per ton of ingots.}$$

If the steam generated were used in a modern turbine with a good vacuum to generate electric energy the amount would be:—

= 253.2 kw.-hours.
Deduct amount used by fan........ = 26.4 kw.-hours.

Leaving a net amount................ = 226.8 kw.-hours.

per furnace which is available for general purposes, equivalent to 54.2 kw.-hours per ton of ingots. Making the same assumptions as before with regard to boiler fuel and efficiency, the fuel equivalent of the steam generated is 583.2 lbs. per hour per furnace, equal to 139.4 lbs. per ton of ingots.

Note.—As the damper on the top of the chimney was open slightly, the products of combustion accounted for in the test do not represent the whole amount available. Had the boiler been larger, more steam could certainly have been generated. (See Table V.)

Table V.

II.—Waste-Heat Boiler on O.H. Furnace of 100 Tons Nominal Capacity.

Boiler—Type: Babcock & Wilcox water-tube. Heating surface, 2,193 sq. ft.
Economizer—Type: Green's patent. Heating surface, 1,200 sq. ft.
Fan—Type: "Sirocco" multi-vane. Diameter of impeller, 50 in. speed, 480 r.p.m.
Duration of test, 77½ hours.
Readings taken at 20-minute intervals.

Average Values of the Data Observed.

Temperature of "products" entering boiler, 422.1° C.
Temperature of "products" entering economizer, 232.4° C.
Temperature of "products" entering fan, 184.4° C.
Temperature of feed entering economizer, 40.8° C .
Temperature of feed entering boiler, 133.5° C.
Steam pressure per sq. in abs., 74 lbs.
Dryness factor of steam (assumed), 0.95.
Total water evaporated, 228,306 lbs.
Water evaporated per hour, 3,728 lbs.
Water evaporated per hour "from and at", 4,045 lbs.
Evaporation "from and at" per sq. ft. H/S., 1.84 lbs.
Electric energy used by fan (kw.-hours), 24.2 lbs.
Equivalent to (brake-horse-power), 32.4.
Draft entering boiler, 1.60 W.G.
Draft entering economizer, 3.05 W.G.
Draft entering fan, 3.15 W.G.

Probable volume of "products" at s.t.p. passing through boiler, economizer, and fan per hour, 600,000 cub. ft.

Heat contents of "products" entering boiler at 422.1° C. in lb. calories per cub. ft. s.t.p., 8.87.

Heat contents of "products" entering economizer at 232.4° C. in lb. calories per cub. ft. s.t.p., 4.73.

Heat contents of "products" entering fan at 184.4° C. in lb. calories per cub. ft. s.t.p., 3.72.

From these data the heat balance-sheets in Table VI have been calculated.

Table VI.

Boiler.

Heat received per hour:—	Lb. calories	Per cent.
In 1,528,000 ft.^{3} "products" at 422.1° C...	5,322,000	91.37
In 3,728 lbs. hot feed at 133.5° C.......	503,100	8.63
Total	5,825,100	100.00
Heat expended per hour:—		
In evaporating 3,728 lbs. hot feed to steam at 74 lbs. abs. and dryness factor 0.95	2,360,000	40.52
In 1,111,000 ft.^{3} "products" to economizer at 232.4° C..............................	2,838,000	48.72
Other losses (by difference)..............	627,100	10.76
Total	5,825,100	100.00

Economizer.

Heat received per hour:—		
In 1,111,000 ft.^{3} "products" at 232.4° C.	2,838,000	94.91
In 3,728 lbs. cold feed at 40.8° C.........	152,400	5.09
Total	2,090,400	100.00
Heat expended per hour:—		
In heating 3,728 lbs. cold feed to 232.4° C.	503,100	15.34
In 1,060,000 ft.^{3} "products" discharged at 184.4° C..............................	2,232,000	79.11
Other losses (by difference)..........	255,300	5.55
Total	2,990,400	100.00

Efficiencies.

$$\text{Boiler} = \frac{2{,}360{,}000 \times 100}{2{,}825{,}100} = 40.52 \text{ per cent}$$

$$\text{Economizer} = \frac{503{,}100 \times 100}{2{,}990{,}400} = 16.83 \text{ per cent}$$

$$\text{Over all} = \frac{2{,}360{,}000 \times 100}{5{,}474{,}400} = 43.11 \text{ per cent.}$$

The theoretical power required to move 1,006,000 cub. ft. of "products" per hour, their volume at 184.4 deg. C. with a suction of 3.15 inches W.G. is:—

$$\frac{1{,}006{,}000 \times 3.15 \text{ in.} \times 5.2 \text{ lbs.}}{60 \times 33{,}000} = 8.32 \text{ b.h.p.}$$

The efficiency of the fan and motor is therefore:—

$$\frac{\text{Theoretical b.h.p.} = 8.32}{\text{Actual b.h.p. taken} = 32.4} = 25.7 \text{ per cent.}$$

During the test the furnace was working at the rate of 4.36 tons of ingots per hour. The amount of steam generated was therefore:—

$$\frac{3{,}728 \text{ lbs. per hour}}{4.36 \text{ tons per hour}} = 855.3 \text{ lbs. per ton of ingots.}$$

If the steam generated was used in a modern turbine operating with a good vacuum to generate electric energy, the amount generated would be:—

	228.1 kw.-hours
Deduct amount used by fan............	24.2 kw.-hours
Net amount available for other work....	203.9 kw.-hours

equivalent to 46.77 kw.-hours per ton of ingots. Making the same assumptions as before, with regard to boiler fuel and efficiency, the fuel equivalent of the steam generated is 542 lbs. per furnace per hour, equal to 124.4 lbs. per ton of ingots.

Note.—In this case also the fan discharges through a short funnel into the air, and the damper plate on top of chimney was slightly open, part of the "products" was therefore short-circuited past the boiler. The furnace bottom gave some trouble during the run of the tests, with the result that the doors were open oftener than they should have been. A leakage of air was also discovered in the flue leading from the furnace, which partly accounts for the low temperature of the "products" reaching the boiler.

Table VII.

III.—Waste-heat Boiler on O.H. Furnace of 60 Tons Nominal Capacity.

Boiler—Type: Babcock & Wilcox water-tube. Heating surface, 2,193 sq. ft.
Economizer—Type; Green's patent. Heating surface, 1,200 sq. ft.
Fan—Type: Keith & Blackman multi-vane. Diameter of impeller, 50 in. Speed, 240 to 320 r.p.m.
Duration of test, 93 hours.
Readings taken at 20-minute intervals.

Average Values of the Data Observed.

Temperature of "products" entering boiler, 577.2° C.
Temperature of "products" entering economizer, 302.8° C.
Temperature of "products" entering fan, 171.5° C.
Temperature of feed entering economizer, 9.5° C.
Temperature of feed entering boiler, 132.7° C.
Steam pressure per sq. in abs., 88 lbs.
Dryness factor of steam (assumed), 0.95.
Total water evaporated, 429,213 lbs.
Water evaporated per hour, 4,616 lbs.
Water evaporated per hour "from and at", 5.286 lbs.
Evaporation "from and at" per sq. ft. H.S., 2.41 lbs.
Electric energy used by fan (kw.-hours), 26.4.
Equivalent to (brake-horse-power), 35.4.
Draft entering boiler, 1.0 inch W.G.
Draft entering economizer, 2.5 inch W.G.
Draft entering fan,, 3.0 inch W.G.
Probable volume of products reduced to s.t.p., 600,000 cub. ft.
Heat contents of "products" entering boiler at 577.2° C. in lb. calories per cub. ft. s.t.p., 12.47.
Heat contents of "products" entering economizer at 302.8° C. in lb. calories per cub. ft. s.t.p., 6.24.
Heat contents of "products" entering fan at 171.5° C. in lb. calories per cub. ft. s.t.p., 3.45.

From these data the heat balance-sheets in Table VIII. have been calculated.

Table VIII.

Boiler.

	Lb. calories	Per cent.
Heat received per hour:—		
In 1,557,000 ft.³ "products" at 577.2° C...	6,235,000	90.95
In 4,616 lbs. hot feed at 132.7° C.......	619,400	9.05
Total	6,854,400	100.00
Heat expended per hour:—		
In evaporating 4,616 lbs. hot feed to steam at 88 lbs. abs. and dryness factor 0.95	2,934,000	42.81
In 1,043,000 ft.³ "products" delivered to economizer at 296.5° C..............	3,050,000	44.49
Other losses (by difference)..........	870,400	12.70
Total	6,854,400	100.00

Economizer.

Heat received per hour:—		
In 1,043,000 ft.³ "products" at 296.5° C.	3,050,000	98.57
In 4,616 lbs. cold feed at 9.5° C.........	43,900	1.43
Total	3,093,900	100.00
Heat expended per hour:—		
In heating 4,616 lbs. cold feed to 132.7° C.	619,400	20.02
In 743,200 ft.³ "products" discharged at 171.5° C.	1,725,000	55.75
Other losses (by difference............	749,500	24.23
Total	3,093,900	100.00

Efficiencies.

$$\text{Boiler} = \frac{2{,}934{,}000 \times 100}{6{,}854{,}400} = 42.81 \text{ per cent}$$

$$\text{Economizer} = \frac{619{,}400 \times 100}{3{,}093{,}900} = 20.02 \text{ per cent}$$

$$\text{Over all} = \frac{2{,}934{,}000 \times 100}{6{,}278{,}900} = 46.73 \text{ per cent}$$

The theoretical power required to move 743,200 cub. ft. of "products" per hour, their volume at 171.5 deg. C. with a suction of 3 in. W.G. is:—

$$\frac{743{,}200 \times 3\text{-in. W.G.} \times 5.2 \text{ lbs.}}{60 \times 33{,}000} = 5.86 \text{ b.h.p.}$$

The over-all efficiency of fan and motor is therefore:—

$$\frac{\text{Theoretical b.h.p.} = 5.86}{\text{Actual b.h.p. taken} = 35.4} = 16.54 \text{ per cent.}$$

During the test the furnace was working at the rate of 3.69 tons of ingots per hour. The amount of steam generated was therefore:—

$$\frac{4{,}616 \text{ lbs. per hour}}{3.69 \text{ tons per hour}} = 1{,}252 \text{ lbs. per ton of ingots.}$$

If the steam generated was used to generate electric energy in a turbine of the type referred to above, the amount would be equal to:—

	290.0 kw.-hours
Deduct amount used by fan............	26.4 kw.-hours
Leaving a net amount of................	263.6 kw.-hours

per furnace which is available for general purposes, equivalent to 71.52 kw.-hours per ton of ingots. Making the same assumption as before with regard to boiler fuel and efficiency, the fuel equivalent of the steam generated is 673.8 lbs. per hour per furnace, equal to 182.8 lbs. per ton of ingots at the rate of output at which the furnace was working during the test.

Note.—The fan in this case also discharges direct into the air through a short funnel, and during the test the main damper was slightly open at the top of the chimney.

It will be noted that the amount of "other losses" in the economizer is excessively large, due either to the pyrometer by which the temperatures were taken at the outlet from the economizer reading too low, or by leakage of air about the economizer causing the assumed volume to be too low. Probably both causes were in operation.

Table IX.

IV.—Waste-heat Boiler on O. H. Furnace of 60 Tons Nominal Capacity.

Boiler—Type: Babcock & Wilcox water-tube. Heating surface, 2,193 sq. ft.
Economizer—Type: Green's patent. Heating surface—1,200 sq. ft.
Fan—Type: Keith & Blackman multi-vane. Diameter of impeller, 50 in. Speed, 450 r.p.m.
Duration of test, 99½ hours.
Readings taken at 20-minute intervals.
The readings are shown graphically on Fig. 1.

Average Values of the Data Observed.

Temperature of "products" entering boiler, 438.9° C.
Temperature of "products" leaving boiler and entering economizer, 303.7° C.
Temperature of "products" leaving economizer and entering fan, 263.5° C.
Temperature of cold feed entering economizer, 29.30° C.
Temperature of hot feed leaving economizer and entering boiler, 129.2° C.
Steam pressure per sq. in. abs., 122.7 lbs.
Dryness factor (assumed), 0.95.
Total water evaporated, 471,770 lbs.
Water evaporated per hour, 4,736 lbs.
Water evaporated per hour "from and at," 5,301 lbs.
Evaporation "from and at" per sq. ft. H.S., 2.42 lbs.
Electric energy used by fan (kw.-hours), 41.8.
Equivalent to (brake-horse power), 56.0.
Draft entering boiler, 1.00 in. W.G.
Draft between boiler and economizer, 3.75 in. W.G.
Draft entering fan, 5.75 in. W.G.
Probable volume of products passing through boiler, economizer, and fan per hour reduced to standard temperature and pressure, 950,000 cub. ft.
Heat contents of "products" entering boiler at 438.9 C. in lb. calories per cub. ft. s.t.p., 9.26.
Heat contents of "products" entering economizer at 303.7° C. in lb. calories per cub. ft. s.t.p., 6.26.
Heat contents of "products" entering fan at 263.5° C. in lb. calories per cub. ft. s.t.p., 5.39.

From these data the heat balance-sheets in Table X. have been calculated.

Table X.

Boiler.

Heat received per hour:—	Lb. calories	Per cent.
In 2,477,000 $ft.^3$ "products" at 438.9° C.	8,792,000	93.46
In 4,736 lbs. hot feed at 129.2° C.......	615,600	6.54
Total	9,407,600	100.00
Heat expended per hour:—		
In evaporating 4,736 lbs. hot feed to steam at 122.7 lbs. abs. and dryness factor 0.95	3,031,000	32.21
In 2,006,000 $ft.^3$ "products" to economizer at 303.7°......................	5,947,000	63.22
Other losses (by difference)..........	429,600	4.57
Total	9,407,600	100.00

Economizer.

Heat received per hour:—		
In 2,006,000 $ft.^3$ "products" at 303.7° C...	5,947,000	97.72
In 4,736 lbs. cold feed at 29.3° C.......	138,800	2.28
Total	6,085,800	100.00
Heat expended per hour:—		
In heating 4,736 lbs. cold to 129.2° C.	615,600	10.12
In 1,866,000 $ft.^3$ "products" discharged at 263.5° C..........................	5,121,000	84.16
Other losses (by difference)..........	349,200	5.72
Total	6,085,800	100.00

Efficiencies.

$$\text{Boiler} = \frac{3{,}031{,}100 \times 100}{9{,}407{,}600} = 32.21 \text{ per cent}$$

$$\text{Economizer} = \frac{615{,}600 \times 100}{6{,}085{,}800} = 10.12 \text{ per cent}$$

$$\text{Over all} = \frac{3{,}031{,}000 \times 100}{8{,}930{,}800} = 33.93 \text{ per cent}$$

The theoretical power required to move 1,866,000 $ft.^3$ "products" per hour, their volume at 263 deg. C. with a suction of 5.75 in. W.G. is:—

$$\frac{1{,}866{,}000 \text{ ft.}^3 \times 5.75 \text{ in. W.G.} \times 5.2 \text{ lbs.}}{60 \times 33{,}000} = 28.18 \text{ b.h.p.}$$

The over-all efficiency of fan and motor is therefore:—

$$\frac{\text{Theoretical b.h.p.} = 28.18}{\text{Actual b.h.p. taken} = 56.02} = 50.28 \text{ per cent.}$$

During the test the furnace was working at the rate of 5.94 tons of ingots per hour. The amount of steam generated was therefore:—

$$\frac{4{,}736 \text{ lbs. per hour}}{5.94 \text{ tons per hour}} = 796.9 \text{ lbs. per ton of ingots.}$$

If the steam generated was used to generate electric energy in a turbine of the type referred to above, the amount would be equal to:—

	320.2 kw.-hours
Deduct amount taken by fan............	41.8 kw.-hours
Leaving a net amount of.............	278.4 kw.-hours

per furnace which is available for general purposes, equivalent to 46.81 kw.-hours per ton of ingots. Making the same assumptions as before with regard to boiler fuel and efficiency, the fuel equivalent of the steam generated is 695.8 lbs. per furnace per hour, equal to 117 lbs. per ton of ingots at the rate of output at which the furnace was working during the test.

Note.—The fan in this case deals with the whole products of combustion, and after drawing them over the heating surfaces of boiler and economizer discharges them back into the chimney.

It will be noted that the efficiencies both of boiler and economizer are very low. This is due to the fact that they are too small for the volume of "products" passing through them.

That the boiler was working quite well is proven by the fact that it evaporated more water than No. III., although the temperature of the "products" was lower. The economizer, on the other hand, was not doing well, probably owing to the fact that it was working with hard water from a loch, with the result that the pipes may have been coated with scale. The high suction required at the fan inlet will also be noted, due to the boiler being too small, and therefore the spaces between the tubes not being large enough for the volume of "products" being drawn through. At the time of writing alterations are being made in the position of the baffles which will enable the "products" to flow more freely through.

Influence of Hot Deformation on Steel

Discussion of Deformation Influence on Steel—Results of Experiments Made in France Indicate Desirability of Maximum Deformation Specifications—Choosing Localities for Test Pieces.

By GEORGES CHARPY.

In France many of the official specifications lay it down that in order to obtain certain parts it is necessary to effect, by means of forging, a reduction of the initial section of the ingot, equivalent to a given figure. These conditions are expressed as the "co-efficient of working," which is equivalent to the ratio of the initial section to the final section, or what amounts to the same thing, the ratio of the final length to the original length. The minimum values assigned to this "co-efficient of working" are generally 3 or 4, and sometimes higher. The question is one that appears to deserve examination afresh, and to be made the object of systematic experiments, the more so as the conclusions which may be arrived at may lead to important modifications in the practice of manufacturing large forgings.

In order to study the influence of hot-working on the properties of steel, it is necessary to take into consideration the local deformation undergone at the very point from which the test-piece intended to represent the quality of the metal is to be taken. If the external form of the finished piece be the only guidance afforded in this direction, it should nevertheless be possible to assume that the deformation has been uniform, at least in certain well-determined localities. This remark is sufficient to exclude, from systematic experiments, the use of pieces obtained by forging under the hammer or the press, at any rate under ordinary conditions. The discontinuous action of such appliances will, indeed, necessarily produce extremely variable local deformations. The successive compressions which allow of there being effected, under the forge or the hammer, the shaping of a block of metal, impart, to a given point in the ingot, a highly complicated path, in the course of which it alternately recedes and approaches the axis, the relative displacement of two neighboring points being even much more irregular. It is only necessary to watch an ingot being forged under the hammer or the press, bearing in mind what has just been said, to realize the great importance of the local deformations; it is more difficult to follow them exactly. An approximate value may be assigned to the variations by making datum marks on the ingot.

It may be taken as an established fact that in a forging the deformation is very far from being uniform, and it is useless, therefore, to attempt to bring out clearly in evidence the effects of hotworking on the mechanical qualities of the steel by taking test-pieces from forgings which have been subjected to more or less heavy drawing down. In rolling, the deformations are very much more regular than in forging, and they may be considered as practically uniform, at any rate in the direction of rolling. Lines originally parallel with the axis of rolling remain rectilinear and parallel during the course of deformation. It may thus be recognized that the rolling of an ingot into bars introduces no dissymmetry along its axis; test-pieces taken from the same bar at equal distances from the axis may be regarded as having undergone exactly the same deformation. It would, perhaps, be straining matters to extend this conclusion to test-pieces taken at different points in the same

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From paper read before fall meeting of British Iron and Steel Institute.

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transverse section, but there is, on the other hand, a dominant reason to forego comparison of such test-pieces owing to the variations in composition and in structure which are inevitable in the transverse sections of any ingot. This can be seen in comparing two bars of different sections by collating the results furnished by test-pieces taken from regions corresponding with the same fractions of the total radius, and therefore with the same region in the mother ingot.

The author then describes certain experiments carried out, and endeavors to determine the influence of hot-working on the properties of steel.

Experiment No. I.—Three identical ingots, of square section with rounded corners (355×355 millimetres) were cast simultaneously. The metal employed was a gun steel, made in an acid furnace from very pure materials—that is to say, of the quality which will best serve to obtain satisfactory results in tests from bars cut across (perpendicular to the direction of drawing down). These three ingots, regarded as identical, were rolled after having been heated under exactly the same conditions, and reduced to the dimensions of 225×225 millimetres for the first, 165×165 millimetres for the second, and 125×125 millimetres for the third. The co-efficients of working were thus 1.7, 3.2, and 6.1. From each of the resulting blooms test-pieces were taken for tensile tests, for shock bend tests, and for notch tests, with both longitudinal and cross notches. These test-bars were all cut from points taken from the same regions of the ingot both in the longitudinal and transverse directions, and were situated at one-third of the distance between the surface and the axis so as to avoid the influence of segregation and of axial porosities; their axes were thus identical from all points of view, except from that of the "co-efficient of working." The test-bars were quenched and annealed under exactly similar conditions (quenched from 850 deg. and annealed at 600 deg. C.), and then subjected to tests.

(a) The tensile strength of each is practically the same; the elongations increase slightly, in the longitudinal samples, under hot working and decrease notably in the transverse test-bars, and the same thing, only much more markedly, occurs in regard to the reductions in area. It is, however, the variation in reduction of area which alone influences the total elongation; the curves of tensile strength being practically identical and super-impossible, up to the breaking point. The fractures vary naturally with the reductions in area; they are normal even in the transverse bars in the case of the bloom which has undergone little deformation, and take an oblique form in the transverse bars which have been strongly worked.

(b) Impact bend tests were made on two bars 24×9×75 millimetres, clamped at one end and subjected to the impact of a 10-kg. tup falling from a height of 1 metre. None of the longitudinal bars could be broken by impact. The transverse bars broke respectively after 29, 27, and 23 blows.

(c) Bars measuring 10×10×53.5. millimetres were notched half-way through and tested under the drop test machine. Two bars were tested from each bloom, the notches being given the two rectangular positions possible in the circumstances. The figures given in Table II. show the work absorbed by rupture, expressed in kilogrammetres and calculated per square centimetre of the section at rupture.

Table I.

	Longitudinal Tests.			Transverse Tests.		
Coefficient of working	Tensile strength	Elongation.	Reduction in area	Tensile strength	Elongation	Reduction in area.
1.7	91.2	20	111	90.9	18	76
3.2	91.6	20	140	90.5	16	57
6.1	90.5	22	170	90.6	12	31

Table II.

Co-efficient of working.	Longitudinal Tests. 1.	2.	Transverse Tests. 1.	2.
1.7	6.5	7.1	5.3	5.8
3.2	7.9	8.3	3.9	5.8
6.1	9.9	10.1	3.5	3.5

The variations are here much more marked and most sharply defined. Hot working increases the impact resistance longitudinally and diminishes it greatly in the transverse direction, the more so the greater the amount of deformation. Within the limits of the experiment the average differs but slightly.

Experiment No. II.—Instead of taking several different ingots two fragments from the same ingot (the same metal as in the preceding experiment), subjected to different amounts of working, were compared. In the first heat the section was reduced from 355×355 millimetres to 225×225 millimetres (co-efficient = 1.7), and, secondly, a piece of the bloom thus obtained was submitted to a second heat and the section reduced to 125×125 millimetres (total co-efficient = 6.1). The piece from the first bloom, which had not been re-rolled, was replaced in the reheating furnace at the same time as the second piece, so that it should undergo the same heat treatment. The results agreed completely with those of the preceding experiment. The tensile tests are given in Table III.

Table III.

	Longitudinal Tests.			Transverse Tests.		
Coefficient of working	Tensile strength	Elongation.	Reduction in area	Tensile strength	Elongation	Reduction in area.
1.7	91.6	18	110	92.2	18	87
6.1	91.3	22	165	92.5	14	54

In the impact bend tests the two longitudinal bars did not break; neither did the transverse test-bar, which had been but little worked. The transverse test-bar which had undergone most working broke at the forty-second blow from the tup. Impact tests on notched bars are shown in Table IV.

Table IV.

Co-efficient of working.	Longitudinal Tests. 1.	2.	Transverse Tests. 1.	2.
1.7	7.5	7.5	5.3	6.0
6.1	9.3	9.5	3.5	3.2

Experiment No. III.—The preceding experiments were carried out on metal chosen in such a manner as to eliminate, as far as possible, the differences between the test-bars taken, both in regard to the amount of work they had undergone and in regard to its direction. It appeared necessary to try the second experiment over again on a metal of the same grade and of current quality (semi-hard basic steel, as used in the manufacture of shells).

An ingot 355×355 millimetres was taken and treated exactly as described above, except that in the heat treatment of the bars annealing was carried out at a higher temperature (650 deg. C.) than in the preceding case, so as to diminish the increase in the tensile strength due to quenching and to get the metal into the condition of minimum brittleness. The tensile test results obtained were as in Table V.

Table V.

	Longitudinal Tests.			Transverse Tests.		
Coefficient of working	Tensile strength	Elongation.	Reduction in area	Tensile strength	Elongation	Reduction in area.
1.7	70.1	18	33	70.7	11	27
6.1	72.7	23	60.5	68.4	4	8

In the impact bend tests the two longitudinal bars broke after 17 and 40 blows from the tup respectively The two transverse bars broke after the eighth blow.

The notched bar tests were as in Table VI.

Table VI.

Co-efficient of working	Longitudinal tests.	Transverse tests.
1.7	3.50	2.00
6.1	9.10	1.50

The experiments described confirm and emphasize a series of results of a qualitative nature obtained earlier.

Results obtained with bars from a large ingot (10,000 kg. and 61 sq. decimetres section) were distinctly inferior to those obtained with bars from a small ingot (800 kg. and 8.6 sq. decimetres section). It would therefore appear to be a certainty that, in regard to pieces tested transversely, a mistake is made every time an attempt is made to improve the quality by increasing the amount by which the metal is drawn down.

Conclusions.

From the collection of facts and considerations contained in the Paper it may be concluded that the amount of the deformation undergone at a high temperature by a block of steel affects the properties of the metal according to a complex law which involves the initial state of the ingot and all the subsequent deformations, and the chief characteristic of which is to create strongly marked heterogeneity. There is found a variation in the properties not only of degree, but of nature as well, according as the direction of the test-bars employed varies in relation to the piece whence they are derived. The total effect is far from being in the nature of a general improvement, as would appear to be looked for whenever, in specifications, a minimum amount of working is prescribed. It would appear, on the contrary, that the result is more injurious than useful, and that, consequently, the specification of a maximum deformation would be more logical. It is impossible to fix a general rule. For pieces working under transverse stresses, such as guns, drawing down lengthwise has undoubtedly an injurious effect, at any rate in mechanical tests required in inspection, and it would be better to reduce it as little as possible. For steel parts of more complex shape the problem differs in each specific case, and it would appear that the only guidance is by studying the conditions beforehand. The designer, who knows how he wants the part he has designed worked, should construe his ideas into deciding the localities from which test-pieces should be taken corresponding with predetermined conditions; these test-pieces should be taken in different directions if these be the conditions under which the material will be employed, and the metallurgist, in order to meet with these fixed conditions, should in each case select the type of ingot to be employed and the nature of the deformations to which it is to be subjected.

Use of Bosh Tuyeres on the Blast Furnace

Results of Investigation at Brymbo Indicate Desirability of Bosh Tuyeres on New Furnace for Basic Iron—Coke Consumption Increased, but Quantity and Regularity in Quality Iron Improved.

By J. HOLLINGER.

The practice of using one or more bosh tuyeres, tempararily installed, to rid a furnace of a particularly obstinate scaffold, probably dates back many years; in fact the French term "tuyeres de secours" and the German equivalent both seem to show that bosh tuyeres were originally used to meet emergencies only, nor were they, apparently, included as an integral portion of blast furnace design, anywhere, much before 1907.

A month or two after first putting them to work at Brymbo early in 1910, the blast furnace manager from a large works in Germany visited the works and

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Paper read before autumn meeting of British Iron and Steel Institute.

showed the author drawings of his furnaces on which bosh tuyeres were illustrated. As far as the author's memory serves they were said to have been at work about a year. During a visit to the Minette districts of France and Germany in the autumn of 1910, the author found them regularly at work on several furnaces, and later visits in 1912, 1913 and 1914, showed that their continuous use was becoming more general both there and in Westphalia. Mr. Henri Verney, of the Société de l'Industrie Minérale, has kindly made inquiries for the author in France, and confirms 1907 as approximately the date when they were first continuously used in French practice. In the United States they are very rarely used even today.

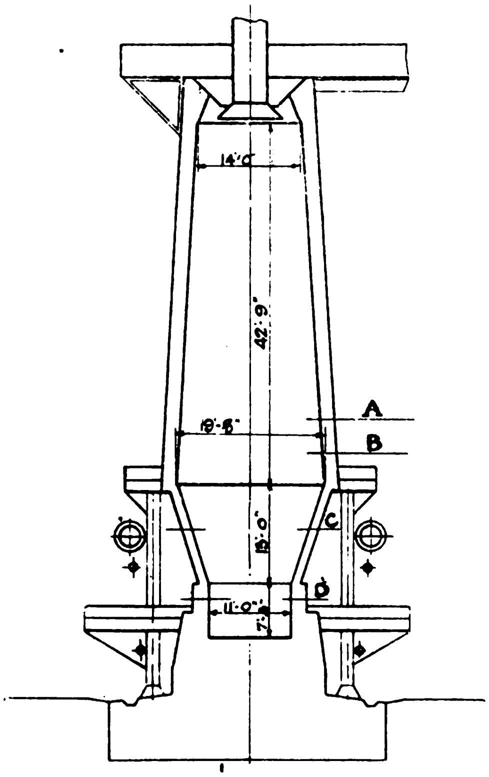

Fig 1.—Location of the Bosh Tuyeres.

They appear to be used mainly on furnaces making basic iron and more particularly where the slag is high in alumina, though they are installed on many large furnaces in Westphalia using a large percentage of Swedish ore.

If it were possible to obtain absolutely ideal physical, chemical and mechanical conditions in every-day blast furnace practice, bosh tuyeres would probably be neither necessary nor desirable. If a furnace were correctly designed for a given output and burden, and regularly so driven, bosh tuyeres would seldom be required, provided the size and quality of the burden, the temperature of the blast and other furnace conditions were kept as regular as is easily practicable on a modern furnace plant. Unfortunately even regular driving cannot be depended on in these days when supplies of raw materials are a source of frequent difficulty, and there is always the temptation to get more out of a furnace than it was designed for. Blast furnace practice must always, and more especially today, be to a great extent a series of compromises, and bosh tuyeres are one of them.

The circumstances which led to the adoption of bosh tuyeres at Brymbo were several years' bitter experience leading to the conclusion that as far as conditions there were concerned the absolutely regular descent of the burden was of greater importance than the absolute regularity of any one other factor in furnace practice.

The furnace which caused so much trouble would now be considered a mere toy, being only 48 ft. high from hearth to stock line, 8 ft. 6 ins. in hearth diameter, and 8,500 cubic feet capacity. During the last eighteen months of her campaign she averaged, however, over 700 tons of basic pig iron per week on a 38 per cent burden, which meant that the iron in the ore charged at the top was tapped as pig iron eight hours later. She had made 550 tons a week and had run months without scaffolding on many occasions, but very different conditions arose when the make was pushed to 700 and even 750 tons a week. Similarly, a furnace making 1,000 tons a week on a 37 per cent burden became an entirely different proposition when it was attempted to obtain the same weekly output from a 30 per cent burden.

Having done everything which at the time seemed feasible to ensure regularity in the size and quality of the burden and its proper distribution into the furnace, and being still troubled with scaffolds, it was decided that the easiest way to obviate them was to instal a second row of tuyeres at some distance above those in the hearth. No information was forthcoming as to the correct height above the hearth for such tuyeres, so we set about getting it for ourselves on the larger of the two furnaces mentioned above, which had then been blowing about eighteen months.

Holes were made at points "A" and "B" Fig. 1, above the mantle plate; 1 in. diameter steel pipes were securely fastened in them and registering pressure gauges installed on branch pipes in such a way that a rod could always be passed through the 1 in. diameter tubes to clean them preparatory to taking each reading. In practice this did not prove necessary, as the tubes were hardly ever found obstructed in any way. Moreover, holes drilled at various points in the casing above the mantel plate entirely failed on every occasion to locate any accumulations on the walls above the bosh. One small bosh tuyere was specially installed at "C," and readings of the pressure inside the furnace were taken at regular intervals by means of a very simple apparatus. A similar apparatus served to take readings at the center of the hearth through the ordinary tuyeres. This apparatus was pushed through the bosh or hearth tuyere, the pressure read, and the apparatus withdrawn in about 30 seconds.

Readings were taken at points "A," "B," "C," and "D," shown on sketch No. 1, every hour to begin with, but the difficulties of keeping the bosh tuyere open with blast only going through it for a few minutes together at intervals of an hour were so great that after two days, readings at this point were given up. In normal practice, the other readings were so regular that after a week we only took readings during periods of abnormal pressures.

The furnace was being blown with a regular volume of air, irrespective of pressure, to a point. The normal blast pressure was 5 lbs. per square inch in the horse shoe main; this was allowed to rise to 9 lbs. per square inch before the volume of air was lessened. If the pressure in the horse shoe main rose above 9 lbs., the volume of air was reduced so that the pressure should under no circumstances exceed 9 lbs. Readings taken over a period of one month showed that though the pressure at "C" and "D" varied over a range of 5 lbs., the pressure at "A" and "B" never varied more than ½ lb. Moreover, this latter variation was probably due to some extent to the size of the material charged into the furnace. The supplies of ore came in on Mondays, Wednesdays and Fridays, and by Sunday morning the bunkers were getting empty and most of the material drawn from them was on the fine side. It was invariably at such times that the pressure at the points "A" and "B," shown on the diagram, was at the maximum. Clearly, therefore, the obstructions when they arose were situated between "C" and "B."

	A		B		C		D		E		F		G	H	Tuyeres Bosh		Tuyeres Main	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	in.	in.	No.	Dia. in.	No.	Dia. in.
1	20	0	12	6	8	0	5	6	9	0	6	0	6	4	5	4	8	5
1(a)	18	6	11	6	7	6	5	3	5	5	9	4	6	4	6	4	8	5
2	21	0	13	0	....		6	6	10	7	2	6	9	...	6	3	12	5–6
3	19	10	11	0	....		5	6	6	6	12	9	9 to	5	5	4 to	9	6
3(a)	19	10	11	0	....		5	6	7	6	11	9	3	5		3½	9	6
4	20	0	12	6	....		7	10	10	7½	0	10½	9	6	4	6	8	5½
5	19	0	11	0	....		5	3	9	5	3	10	6	4	5	4	8	5
5(a)	21	9	12	6	....		7	0	10	9½	3	11½	6	4	5	4	10	6
6	19	8	11	0	7	3	5	3	9	4	5	10	6	2½	4	2½	8	5
6(a)	19	8	11	0	7	3	5	3	11	0	4	2	6	3	4	4	8	5

It was, therefore, decided to instal four bosh tuyeres at a height of 9 ft. 4 ins. above the center line of the hearth tuyeres. Each bosh tuyere is surrounded with a cooler and rigged in a manner exactly similar to the ordinary hearth tuyeres.

The view was taken that the use of bosh tuyeres was incorrect, theoretically, and being anxious not to overdo the quantity of blast, introduced at this point, an internal diameter of 2½ in. was selected for the bosh tuyeres. A few weeks' experience showed that this was on the small side, and the diameter was incased to 3 in., and subsequently to 4 in. The nose of the tuyere was not more than 3 in. beyond the brickwork of the bosh, which consisted of a complete rivetted steel plate sheeting, lined with 13½ in. brickwork.

No break through has ever occurred anywhere in the bosh, nor has a hot spot above the bosh tuyeres ever been noticed, though on rare occasions hot spots occurred above the hearth tuyeres before the bosh tuyeres were installed.

The table below gives a summary of information that a number of friends in this country have been kind enough to give the author and Fig. 2 serves as a key thereto. The table shows that the number, size and position of bosh tuyeres vary over a fairly wide range at different places.

As to the results to be obtained by the use of bosh tuyeres, the author can here speak only from his own experience, and must rely on the members present to confirm or refute it from their own.

The figures given were obtained from a furnace with a hearth diameter of 11 ft., a bosh diameter of 19 ft. 8 in., a stock line diameter of 14 ft., and a bell diameter of 9 ft. The height from hearth to the bottom of bosh was 7 ft. 3 in., from the bottom of the bosh to the top of the bosh 13 ft., and from the top of the bosh to the stock line 32 ft. 9 in., the total capacity below the stock line being 12,600 cubic feet (see sketch No. 1). This furnace is blown with eight hearth tuyeres, those on either side of the tap hole being 5 in. diameter, while the other six are 5½ in. diameter. The air blown when bosh tuyeres are in use varies from 14,000 to 16,000 cubic feet per minute, according to the coke available, and in normal practice the pressure is 6 lbs. per square inch.

The furnace was blown in in the late autumn of 1908, and during the whole of 1909—running on a 35 per cent burden—made an average of 778 tons of iron per week, 74.9 per cent of which contained less than 1 per cent of Silicon, and less than 0.1 per cent of Sulphur. The coke consumption over the whole period averaged 22.4 cwts. per ton of pig iron. Throughout this period the furnace was working without bosh tuyeres, and troubles with scaffolds were not infrequent, particularly when any attempt was made to

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increase the driving. Bosh tuyeres were inserted early in 1910. During the coal strike in 1912, the stock line was repaired, and over the whole of 1913 the furnace was running with four bosh tuyeres, at least three of which were continually open. The average make per week on a 37 per cent burden was 1,016 tons; 89 per cent of which contained less than 1 per cent of Silicon and less than 1 per cent of Sulphur. The coke consumption during this period was 23.1 cwts. per ton of pig iron. The two years, 1909 and 1913, are given, because in each case the furnace lining had only been in use about a year, and, as far as the condition of the furnace itself is concerned, the comparison therefore is a sound one.

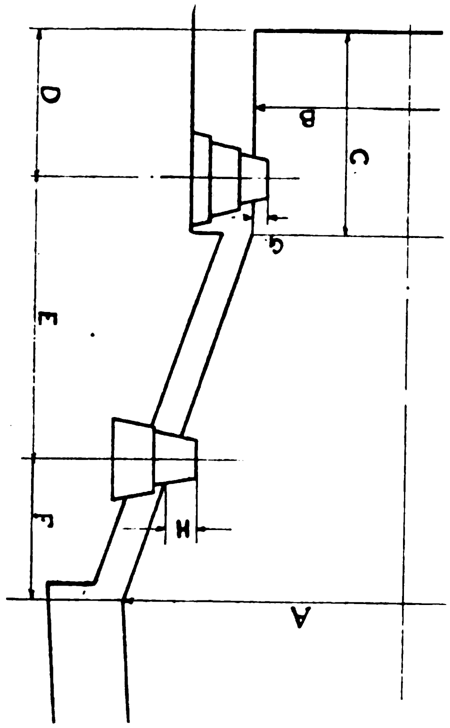


Fig. 2—Dimensions shown on accompanying table.

After allowing for the fact that the burden in 1913 was 2 per cent richer than in 1909, the increased output due to the use of bosh tuyeres may be estimated at approximately 20 per cent.

During the year 1916, the furnace was working on a very much leaner burden; the average throughout the year was only 30 per cent. With this, the average make was 872 tons a week, of which 85 per cent contained less than 1 per cent of Silicon, and less than 0.1 per cent of Sulphur. The coke consumption on this burden was 25.9 cwts. Bosh tuyeres were used throughout the year.

As a result of his experience, the author would have no hesitation in providing for the inclusion of bosh tuyeres in any new furnace in which it was intended to make basic iron; they could then be rapidly installed if occasion arose. The figures given will show that their continuous use at Brymbo has meant not only a very considerable increase in the quantity of iron made, but a greater regularity in its quality. Against this, it cannot be denied that the coke consumption per ton of pig iron has been increased to a slight extent. By keeping the proportion of air blown through the bosh tuyeres to the lowest practicable minimum, the increase in coke consumption has not exceeded ½ cwt. per ton of pig iron, which is a small price to pay for the other advantages derived. Part of this increase may be due to the increased speed of driving. On a given burden there is a maximum economical speed of driving for every furnace; any lower rate of driving results in increased fuel consumption to meet the greater radiation losses, and on the other hand any higher rate of driving involves incomplete preparation of the burden in the upper part of the furnace, and greatly increased work in the melting zone and the hearth, with a correspondingly increased fuel consumption.

When the furnace referred to is making 1,000 tons a week, her output of pig iron per twenty-four hours is one ton for every 87 cubic feet of furnace capacity, whereas for the most economical results from the burden we are using it should not exceed one ton of pig iron per twenty-four hours for every 100 cubic feet of furnace capacity.

All the tuyeres at Brymbo—both hearth and bosh—are installed on a system which was patented some years ago by Mr. W. J. Foster. The patent has, the author believes, run out, but his experience of the system has been so entirely satisfactory that he ventures to allude to it here.

The water inlet pipes to the tuyeres are coupled to a ring water main round the furnace in the usual way, buy, in addition, the discharge pipes are all coupled to a similar ring main placed below the tapping platform. This main is coupled to a syphon or pump, so that it is always under partial vacuum. In this way, though the water passing through the tuyeres may be greater in volume than in the usual system, the pressure in the tuyeres themselves is zero or below, and consequently it is possible to run with quite a large hole in a tuyere and yet admit no appreciable quantity of water into the furnace hearth. Not infrequently a tuyere has been taken out which on examination proved to have a hole 4 in. long, varying in width from 1/16 in. to ½ in., and yet the failure of the tuyeres had not involved any change in the grade of iron we were making.

Many furnaces are constructed with the tapping platform only very slightly above pig bed level; in these instances, it is not such an easy matter to couple the hearth tuyeres on the vacuum system, but bosh tuyeres are always placed at such a height that it is easy to adopt the arrangement in their case, and from the author's experience he would have no hesitation in advising everyone to do so, as leaks from bosh tuyeres are apt to be a good deal more troublesome than those at the hearth tuyeres.

Principles of Open Hearth Furnace Design

Actual Calculations and Principles Involved in the Design of Open Hearth Furnaces—Pressure in Furnace—Port Ends. Ratio of Air to Gas Passages — Flue and Valve Diagram.

By CHAS. H. F. BAGLEY.

PART I.

In order to melt steel at all the first requirement is an exceedingly high temperature, and it can almost be said that it is hardly possible to attain too high a flame temperature, provided the flame is under control and not allowed to impinge direct on the brickwork. As in the blast furnace, so in the steel furnace, output and efficiency are functions of the average temperature attainable, rather than of the heat units generated; for temperature is the factor which determines the efficiency of utilization of such heat units. The chief object of regenerating gas and air is thus not so much the recovery and return to the hearth of a proportion of the waste-heat units, but rather to enable a higher flame temperature to be reached, by means of highly superheating both gas and air before bringing them into contact. It is important, therefore, that the highest possible temperatures should be reached in the chequer chambers, so that they may be realized in both gas and air on reversing; and also that the chequerwork should be deep enough to allow a high average temperature to be maintained throughout each reversal. Consideration of the subject of theoretical flame temperatures shows that to realize the maximum it is important to provide not only a rich gas, but a dry gas and air (very important points, but outside the subject of furnace design), together with the minimum excess of air for complete combustion, and the maximum initial temperature on each. It is important that the initial temperatures of gas and air should be approximately equal throughout; for the fact of one being higher than the other rather implies that the other is less than it might have been, and the resulting flame temperature correspondingly lower. In designing the furnace, these points should always be taken into account; and the heating surface, and supply of heat to gas and air chambers respectively, should be arranged accordingly.

Though these points may appear to be minor matters, it should be remembered that their effect is cumulative, for a higher flame temperature results in a shorter but more intense flame, which allows more gas to be carried, with a greater development of heat in the furnace and a higher temperature of outgoing gases, and this, in turn, results in hotter chequers and a higher temperature of gas and air on reversal, and further increase of flame temperature, etc., till the furnace becomes considerably hotter—and the most effective way of keeping the heat down is by frequent charging and tapping.

The author worked for some months on such a furnace in Germany in 1904—carrying out the so-called "Martin process"—with 75 per cent of scrap, for spring, tyre, and axle steels, and tapping 12-ton heats every 4¼ hours as regularly as clockwork, and all hand-charged, too. The average make was 36 heats (436 tons) per week (start charging Sunday 9 p. m.—last tap before Sunday 6 a. m.—12-hour shifts—average life 390.6 charges—repairs cost 2.03s. (bricks and labor)—wages cost 3.80s.—coal consumption 25.54 per cent.—ingot yield 95.34 per cent.); while some new 50-ton furnaces, machine-charged, at the neighboring works of Thyssen at Mulheim, making plate steel by the same process, were getting 18 to 20 charges (900 to 1,000 tons) weekly and a life of 460 to 520 charges.

A keen furnace is especially important for such practice, so that the charge can be melted quickly (without risk of losing the carbon), and the proportion of pig-iron and lime used (and slag made) reduced accordingly; thereby also reducing the period of boiling for tapping, and speeding up the whole process. The effect of moisture on the flame temperature of the gas should be thoroughly appreciated, and the amount present kept down by all simple and reasonable means —i. e. producer coal should be dry and protected from the weather, and excess of steam in blast (passing through undecomposed) should be avoided. In the chequer chambers it is liable to dissociate into H_2 and free oxygen, which at once attacks hydrocarbon gases and/or CO present, so that partial combustion takes place in the chambers at the expense of the quality of gas arriving at the furnace.

Before proceeding to the subject of combustion and volumes, it is well to consider the conditions of pressure, existing in the furnace, flues, and valves, etc., and the forces behind gas and air, and in the chimney. The incoming gas will usually have behind it an initial pressure of 1 to 2 in. w.g., but is reduced by the regulating valve to suit the requirements of the furnace; while behind the incoming air there is only the difference in density between two columns of air of atmospheric and regenerated temperatures respectively, and of height equal to that between the bottom of the chequer chambers and the level of the air port.

From paper read before fall meeting of British Iron and **Steel Institute.**

PRODUCTION TOPICS

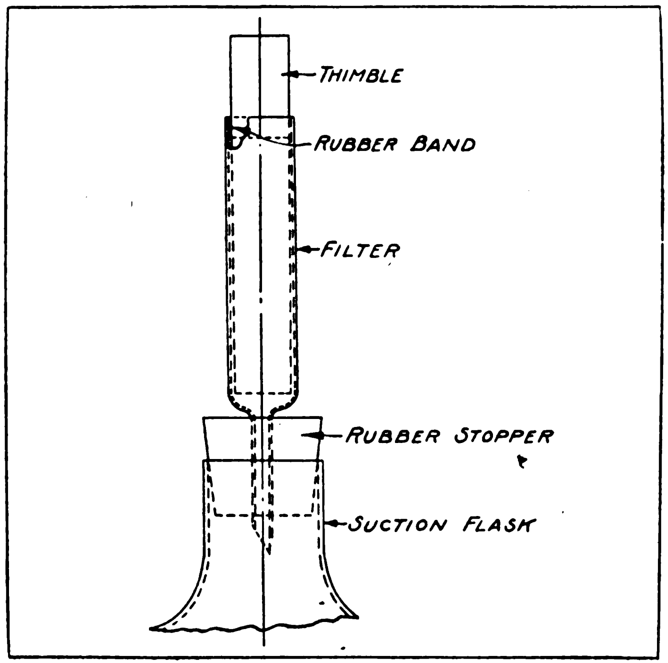
A RAPID METHOD FOR THE DETERMINATION OF GRAPHITIC CARBON.

Each year brings an increase in the demands on chemists doing foundry work. The increase in the production of cast iron containing steel scrap in variable proportions, and the recent investigations on cast iron has brought the foundry to a point where the element carbon is being considered.

The following rapid method has been found suitable for routine work in determining total and graphitic carbon in cast iron. A brief description of the combustion furnace and train will give an idea of the apparatus used.

Oxygen under pressure is conducted through a Y-glass tube to a Fleming mercury gage at one end, and from the other end to a potassium hydroxide (K O H, 1:1) jar. (E and A, 2796c.) It next goes to a jar (E and A, 2796e), the lower half of which contains $CaCl_2$, the upper half soda lime, then to a mercury valve tube (E and A, 2796a), then to a Hoskins combustion furnace with 24-inch juartz tube glazed.

The outlet part of the train consists of a zinc jar (E and A2796h), and phosphoric anhydride jar (E and A, 2796i). The gas is collected in a Vanier absorbent and weighing jar filled with liquid potassium hydroxide (K O H, 1:1) and stick (broken) potassium hydroxide. At the outlet end of the furnace a platinum couple is inserted with a small pressure tight quartz tube through a two-hole stopper so that the couple end is about over the boat position in the furnace. The apparatus is tested for leakage by using aspirator bottles.



Sketch of apparatus.

Samples of cast iron are ground to pass a 60-mesh sieve. For total carbon twice the actor weight (0.5454 gram) is placed in an alundum boat filled with 90-mesh alundum. Better results are obtained with the use of red lead. From one to two grains of red lead are placed in the alundum boat and the iron sample distributed on the red lead. It is advisable to run a blank determination on the red lead.

Boat Placed in Furnace.

The boat is placed in the furnace which is at 1750 to 1800 degrees F. and oxygen passed at about 200 cubic centimeters per minute. The combustion proper is complete in from six to eight minutes and from 12 to 15 minutes more is ample for forcing all the gas through the train into the weighing apparatus.

For the graphitic carbon determination a one-gram sample (60 mesh) is transferred to a 150 cubic centimeter beaker, 40 cubic centimeters of nitric acid (1.13) is added and gentle heat applied until the solution is complete. It is then boiled for five minutes and the graphite allowed to settle. Filter into the thimble as described below using hot water. Wash five times with hot dilute hydrochloric acid, then 10 times with hot water. Place the thimble in a drying oven at 110 degrees C. for 30 minutes, then place in the combustion furnace, open end in first, and proceed for regular carbon determination.

The thimble is a Norton alundum extraction thimble No. 7338—R. A. 360, measuring 15 millimeters outside diameter by 90 millimeters high. This is placed into a carbon filter tube 16 millimeters inside diameter and an air-tight joint made by using a rubber band, as shown in the accompanying illustration. A regular suction flask and water filter pump is used.

The following table gives some of the results obtained:

No.	Sample	Total Carbon Red Lead Used Per Cent	Graphitic Carbon Per Cent
1.	Gov. Iron C.............	2.80	2.30
2.	Gov. Iron, D............	2.49	1.90
3.	25 per cent steel........	3.00	2.20
4.	Gov. Iron C.............	2.81	2.29
5.	Gov. Iron D............	2.48	1.89
6.	25 per cent steel........	3.02	2.19
7	Gov. Iron C.............	2.80	2.29

The 25 per cent steel sample was a cast iron in which 25 per cent of steel was used in the mixture. This iron analyzed as follows: Manganese, 0.60 per cent; silicon, 1.80 per cent; sulphur, 0.107 per cent; phosphorus, 0.40 per cent—From paper read before American Foundrymen's Association.

STOKER MANUFACTURERS ASSOCIATION.

At a meeting in Cleveland on August 1, 1918, an association was formed of the stoker manufacturers of the United States. The principal reason for getting together was to place at the disposal of the government the entire facilities of the stoker industry to the end that everything possible might be done to help out in the national emergency. Even after the war, however, it is expected that great benefit will be obtained by the Association members in the discussion of subjects of interest and value to the stoker industry; in the advancement and improvement of that industry; in the standardization of stoker manufacture and application; and in the promotion of a spirit of coöperation among its members for improved production and increased application of stokers. Practically all of the builders of mechanical stokers are included as charter members of the association.

NEWS OF THE PLANTS

The first steel work to be fabricated at the plant of the Birmingham Steel Corporation, Birmingham, Ala., now in course of construction, will be for the erection of a new unit to the steel works. The initial contemplated capacity of the plant will be increased by the construction of this extension and arrangements have been made to secure material for rolling shapes as soon as the plant is in position to fabricate. It is expected that by next March the entire works will be producing material for the Mobile Shipbuilding Company, with which it is affiliated, for the construction of steel vessels. Work in the meantime will be devoted to the completion of the first unit of the plant and following, the second unit, as now planned, affording maximum production in the spring for fabricated material for shipbuilding. Henry Leon Brittain is president.

The Milliken Brothers Mfg. Company, Woolworth Building, New York, recently organized to succeed Milliken Brothers (Inc.), established 1857, is planning for the establishment of a steel fabricating works in the vicinity of New York. The former plant of the company at Milliken, Staten Island, is now being used by the Downey Shipbuilding Corporation for the construction of vessels for the government. The proposed new plant of the company will be used for the production of sections used for the Standardized Truss Unit System, a patented system of all-steel building construction designed by J. E. Jennings, vice president and secretary of the new organization. Both the Army and Navy departments of the United States government ordered this system for the construction of airplane hangars, balloon buildings and other structures, while one of the government shell-loading plants has over 250 buildings of this type of construction. The new works will also be provided with facilities for the manufacture of galvanized steel transmission towers, galvanized steel wireless towers and special steel poles. Such structural shapes as angles, channels, etc., are used in the manufacture of these specialties. C. T. Clack, for many years with the United States Steel Corporation, is president; and Robert Grant, iron and steel merchant, treasurer.

The Vulcan Steel Products Company, 120 Broadway, New York, manufacturer of iron and steel specialties, is reported to be negotiating for the purchase of the steel works of C. Pardee, Market street, Perth Amboy, N. J., known as the C. Pardee Works, heretofore used for the production of billets, bars, etc. The property is located on the bank of the Raritan river, in the western section of the city, extending to Smith street, adjoining a tile works operated by the Pardee interests. It is said that following purchase, the new owner plans for additions and improvements to increase the present capacity.

The Midvale Steel & Ordnance Co., Widener Bldg., Philadelphia, Pa., has commenced the erection of several additions to its Nicetown steel works for increased capacity for the manufacture of guns for the government. The new extensions will include a one-story building, about 175x275 ft., to be equipped as a forge shop, estimated to cost $50,000; improvements and extensions in the present pattern works, and electric power plant, about 44x45 ft., for works operation.

The ordnance department, United States government, has purchased a tract of property consisting of 17 acres of land at Fox, Roberts and Stokley streets, Philadelphia, as a site for a proposed new gun manufacturing plant. The new works, it is understood, will be equipped for the production of large caliber guns, and will include all departments of operation for the finished product.

The New York Shipbuilding Company, Camden, N. J., has commenced the construction of a new plate and angle shop at its plant to replace the structure recently destroyed by fire with loss of about $200,000. In connection with the new works of the company now in course of erection, a plate and angle shop, about 200x790 ft., will be constructed, said to be one of the largest structures of its kind ever erected. The structure will be provided with machinery and equipment for handling structural shapes of all kinds for shipbuilding work. The entire plant, including other structures devoted to steel operations, is estimated to cost between $8,000,000 and $10,000,000. M. A. Neeland is president.

The War Industries Board, Washington, has authorized the North Alabama Rolling Mill Company, Sheffield, Ala., to make extensions and improvements in its plant to cost about $250,000 . The proposed work will include an addition to increase the present capacity, and a number of important improvements in the existing works to facilitate production. The plant is being used for the production of steel products for the government.

Construction of the superstructure for the new addition to the plant of the McClintic-Marshall Company, Pottstown, Pa., has been commenced, and it is expected to have the structure ready for occupancy at an early date. The new building will be used for the fabricating of steel for ship construction and with equipment is estimated to cost about $500,000. The structure will be about 390x590 ft. The works will be devoted to government construction.

The Witherow Steel Company, Pittsburgh, Pa., has acquired the property and works buildings of J. E. Meyers at Penn Station, near Jeannette, Pa., for a consideration of about $75,000. The company has been operating a plant at Neville Island which will be closed down through the government's occupancy of this site for a new gun works. The property purchased, consisting of about 3¾ acres of land, with two-story buildings, averaging about 50x150 ft. and 30x50 ft., will be occupied by the steel company as soon as the necessary machinery and equipment can be installed, transferring a portion of the work now being done for the government under contract, at the Neville Island plant, to the new location.

The Bethlehem Steel Company has recently blown in its No. 13 furnace at the Steelton, Pa., works. The furnace has been out of service for some time past. The Republic Iron & Steel Co., Youngstown, O., is said to be planning to blow in its No. 3 furnace at an early date. The Alabama Company, Birmingham, Ala., has completed repairs to its furnace at Ironaton, and is planning to shut down a second furnace at this plant for repairs and improvements. The company is also planning to blow in its second furnace at the Gadsden works.

The Columbian Iron Works, Chattanooga, Tenn., is planning for the rebuilding of its shell works recently destroyed by fire with loss estimated at about $75,000. The company has been operating its plant for the production of material for the government.

Some Pointers on By-Product Coke Oven Operations

BY-PRODUCT COKE FOR FOUNDRIES.

By T. A. Galligan.

It seems but a very short time ago when by-product coke was looked upon by foundrymen as unsuitable for cupola fuel, and a thing to be avoided. The peculiar appearance of by-product coke was responsible to a great degree for this prejudice. Coke from by-product ovens was not taken seriously as a real metallurgical fuel, because it appeared to be everything that the so-called standard beehive coke is not, and to have nothing in the way of the many excellent qualities that the beehive coke possesses. There could be no comparisons because the two classes of coke are different things, and therefore, cannot be considered together. If these views had been correctly appreciated the history of the by-product coke oven would have been completely written before this time. It was not until 1897 that the production of by-product coke in the United States began to be a noticeable curve on the total coke production chart.

On Aug. 1, 1918, only two decades later, the production of by-product coke, plus the capacity of by-product ovens then building, was equal to the beehive coke production as of Aug. 1, 1918. It is estimated that the production curve of by-product coke will cross the beehive curve before the end of 1918 and when this is accomplished it is doubtful if beehive production will ever again equal by-product tonnage. The vast increase in government requirements for by-products as well as coke, has hastened the installation of many by-product oven plants that ordinarily would not have been built so soon, but the natural development of the by-product industry would have crossed the curves in a very few years by a continuance of the prewar increase. The needed increase in coke production could hardly have been accomplished through the beehive type of oven, as coal tonnage is available for by-product oven use that the beehive type cannot coke satisfactorily. The modern by-product oven has had its development in the short space of 20 years. It is assuredly all modern, even including the types that the coke master of today considers out of date. The most pronounced change and improvement has been in size, the 4½-ton capacity oven of 20 years ago having grown to a 15 and 20-ton capacity oven in the most recent installations, yet the small ovens are in some cases still performing their daily tasks in a most creditable manner.

The presence of a by-product coke plant is a pronounced asset to adjacent foundries and should be the source of their coke supply if it can be arrangaed. Foundrymen should get in close touch with the new ovens and see that the best coke for their purposes is produced. Do not leave all the work of experimenting in the hands of the coke man. Be a party to the development of a suitable produce, and do not expect to withhold your support until the ovens are producing exactly the kind of coke you want or need. The foundryman does not know in many cases what is wrong with a certain coke which may not suit him and therefore it is difficult for him to do much real co-operating in its improvement. If the foundryman, however, has the real spirit of co-operation and interests himself in working the problem out, he will at least get some very valuable information and will also probably get a better coke.

Coal Mixtures a Factor.

In the case of some ovens, the most favorable branch of trade may be other than foundries, for instance, blast furnaces. A good blast furnace coke is not always a satisfactory cupola coke. A change in coal mixtures may be necessary to get the right foundry product. The volume of available foundry tonnage may not be sufficient to warrant or permit constant operation of a portion of the coke plant on foundry coke. Foundrymen should then group their orders and have the coke plant make special runs for them on designated days, if such a thing can be arranged. The ovens may be located where the disposition of undersized coke is difficult or impossible. In this case the foundryman should not exact the usual foundry screening, but accept run-of-oven coke and use the small coke in core ovens, etc.

I have presented this matter on the theory that ability to obtain coke near home is of more advantage to the foundryman than his patronage is of value to the coke plant, and this is true in a great many instances. The foundry consumption is less than 10 per cent of coke production, so it is apparent that cupola tonnage is not of great importance to some coke plants, while ability to obtain a coke supply nearby is an asset to the foundryman. He is the one to suffer from delays in transit, etc., not the shipper.

Why Does Coal Coke?

For those ovens making a specialty of foundry coke no urging by the foundryman should be necessary and generally speaking it is not. All possible care is taken in the selection of proper coals for the character of the coke depends largely upon the character of coal or coals used to produce it, as well as the degree of heat and the method of applying it. Considerable investigation has been made upon the subject of what makes coal coke, but it is not yet certain what controls this. A French chemist, M. Lemoine has isolated a substance which he calls "carbene," and which he thinks is the real essence. The bureau of mines of the United States has conducted extensive experiments and written the story of its conclusions, but after all not much is known about the subject. The only way to determine it satisfactorily is by test, when it is found some coals will coke and some will not.

While the precise coking substance is not known, it is recognized in general that the resins that were contained in the original vegetable matter from which the coal was formed constitute the cementing body necessary in the manufacture of coke, and the presence of the proper percentage of these resins is essential for the coal to be of good coking quality. When there is an excess of these resins as in the fatty gas coals, a good coke can be made by adding a proper percentage of a coal which is deficient in the resins, and which perhaps has other advantages such as a low ash or a low sulphur content.

All coking coals will not mix, for coals are like people —some do not take well to others. For two coals to coke together well, it is important that they should be coals which become plastic at practically the same temperature. With the modern by-product oven it is possible to produce good coke from coals that were formerly considered inferior. The modern plan involves the mixing of coal so as to correct with one coal the deficiencies that may exist in one or two others.

From paper read before Milwaukee meeting of American Foundrymen's Association.

INDUSTRIAL RELATIONS

WOMEN IN INDUSTRY.

The one factor that looms largest in industry today is employment. The draft has taken 2,000,000 men and may take 3,000,000 more. To maintain each soldier it is estimated that 6½ persons are required in industrial lines, which means 32,500,000 transferred from peaceful pursuits or private life to war activities. This is a fact that should be realized now; "the path of failure runs along the stream of procrastination."

But how are we to get this vast army of workers? The answer is: Older men, boys and women—there are no fair weather signs in the labor skies otherwise.

There are today 1,500,000 women in war industries alone; in canneries, textile mills, knitting mills, munitions plants, shoe plants and elsewhere in this country, and in England they are employed even in shipbuilding, a ship having been launched on the Clyde recently built almost entirely by women labor. They are at the lathe, at the forge, in rolling mills and foundries abroad and for many years have been employed by the Germans at Krupps, at Creuzot in France and elsewhere. They are engaged as section hands on railroads, as conductors on surface roads and subways, in tan yards, papermaking, glass bottle making, woodworking; in potteries, brickyards, metal spinning, paint and varnish making, sugar refineries and in so many other occupations we have been accustomed to look upon as belonging exclusively to men that there is not space to catalog them here.

> *In the industrial world today there is probably no problem of more vital importance than the question of "Industrial Relations." By this we mean the adjustment between the two apparently divergent factors—the necessity for increased production and the lack of skilled labor. This problem is not a temporary one, whether the war ends six months or 10 years from now, old conditions have gone and for economic reasons will not return for a long time. After the war, each civilized nation will endeavor to maintain a sufficient trade to pay its debts. Competition will be increasingly keen. The United States in particular is just starting the solution of a problem which has already been solved to a marked degree of efficiency by European nations. For these reasons "The Blast Furnace and Steel Plant" has decided to maintain a regular department devoted to this topic. The experiences of our readers are earnestly sought, in the hope that through our columns we may disseminate information beneficial to the industry and its members regarding this problem.*
>
> *We shall from time to time discuss methods which have been employed in other industries than the steel industry, insofar as such experience may be fundamentally applicable to the steel industry.*
>
> *This department was formerly devoted to "Industrial Safety." From now on we shall recognize safety matters only as one of the factors entering into the problem of industrial relations.*

Many increases in production might be cited, but one will serve to illustrate our contention. We are not personally conversant with the circumstances, but are reliably informed that in the core-room of the Bessemer Foundry Co., a job previously costing about $5 was done by women for $1.80. That's going some!

The need for workers will not end with the war, for Europe must be rebuilt—and that largely by America. Years will be required; hundred of thousands of foreigners are preparing to return to their own countries and their places must be filled. Our returning army will not be sufficient to supply the demand.

As further evidence of the ability of women, note the following from the New York Sun of March 9, "British women have clearly demonstrated their superiority over men in the manufacture of gun shells. Sixty-one per cent of all the shellmakers in Great Britain are women and this dilution of labor is continuing rapidly, it was stated officially here today. It is found that the greater the percentage of women the greater the output.

"The forthcoming monthly bulletin of the bureau of labor statistics shows that in a 10-hour day women are able to turn out twenty-four 9-inch shells, whereas 10 or 11 is the average for men."

In order to obtain a consensus of opinion upon the subject of women in industry, a questionnaire was mailed some months ago to manufacturers all over the country and to prominent labor leaders as well.

A condensation of the replies shows that the need for more labor power exists and will become increasingly urgent as time proceeds.

Two Principles to Follow.

The questions of ability, adaptability, reliability and productivity all having been determined in their favor, there remains the factor of reward. As a rule, it has been the practice to pay women less than men, but the present crisis will eliminate the differential, as it should, a square deal becoming the rule instead of the exception.

One principle which would be given consideration in the matter of using women is as follows:

Most of the women who will go into industry are the future mothers of the race and the wives of our sons. Another which must be adhered to in safeguarding our women is:

There must be no charity about what is done nor must the attitude toward them be a patronizing one.

With these in mind, we can proceed to the matter of our questionnaire.

The questionnaire attracted no little attention and we understand that it will be a subject for discussion at the next meeting of the industrial betterment committee of the National Association of Manufacturers. A great many requests have already been made for the conclusions, including government officials interested in the subject.

To place results of this investigation in the most logical order, it was decided to rearrange the subject as follows:

A—The Work to be Performed by Women.
B—Find the Women.
C—Selection of Women.
D—Training Women.
E—Wages, Hours and Fatigue.
F—Working Conditions.
G—Living and Social Conditions.
H—State Laws.
I—Co-operation of—
  1—Labor Unions.
  2—Women's Organizations.
  3—Government.
J—Post-Bellum Considerations.

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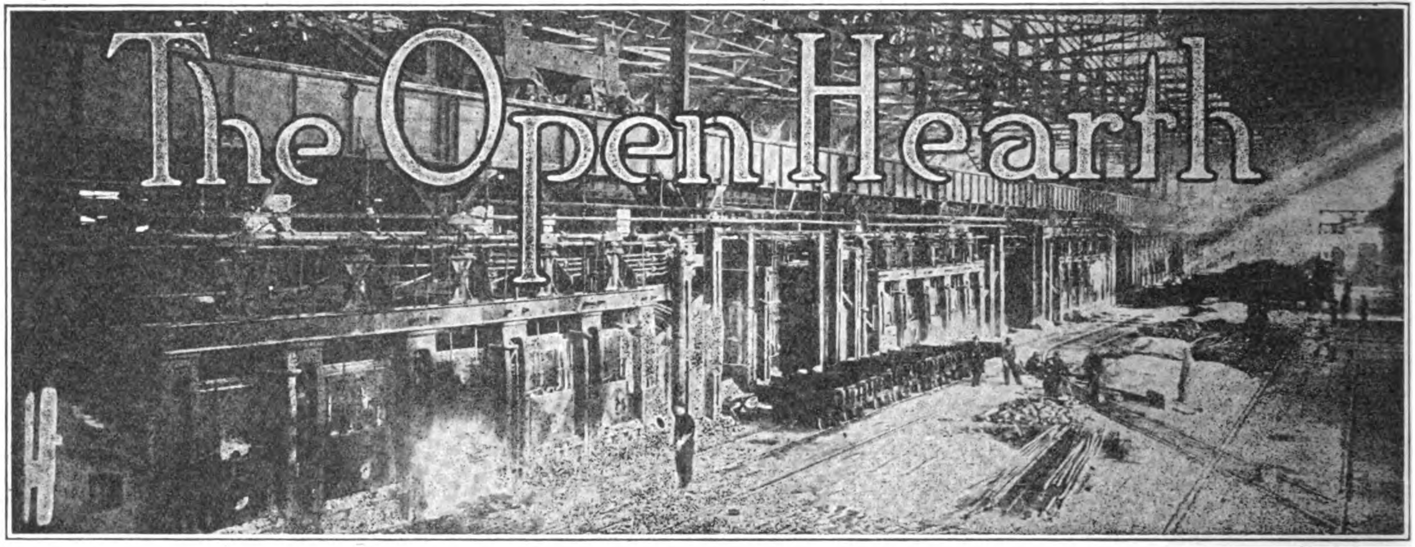
*Abstract of paper prepared by C. E. Knoeppel and M. J. House and presented before the last meeting of the American Foundrymen's Association.



The Open Hearth

F. J. Ryan has resigned as secretary-treasurer and general manager of the Electric Furnace Construction Company, Philadelphia, and disposed of his interest in that organization, to become secretary-treasurer and general manager of the American Metalurgical Corporation, Franklin Trust Bldg., Philadelphia, in which he is a stockholder. The American Metalurgical Corporation controls the Philadelphia Electric Corporation, producer of steel castings, with a plant located at Conshoken, Pa., of which Mr. Ryan is general manager.

V V

George W. Peffer, general superintendent of the open hearth department of the plant of the Republic Iron & Steel Co., at Youngstown, has resigned to become manager of the works at Buffalo for the Donner Steel Company.

V V

C. E. Crothus, head of the blast furnace department of the Youngstown plant of the Republic Iron & Steel Co., has been promoted and his duties include that of general superintendent of the open hearth department.

V V

W. E. Leventry, who has been with the Republic Iron & Steel Co., about six months has been appointed superintendent of the open hearth department.

V V

S. R. Vanderdeck resigned as vice president of the Electric Furnace Construction Company, Philadelphia, and has been elected president of the American Metalurgical Corporation, Franklin Trust Bldg., Philadelphia, which concern is erecting an experimental plant at Conshocken, Pa., where tests on steel and alloys will be conducted.

V V

Frank P. Fahy, consulting engineer, Hudson Terminal Bldg., New York, has been awarded the John Scott legacy medal and premium for the development of the Fahy permeameter, by the city of Philadelphia, acting on the recommendation of the Franklin Institute.

V V

W. C. Munn, purchasing agent for the Brier Hill Steel Company, Youngstown, Ohio, has resigned to take a position in the ordnance department of the government at Washington, and will be succeeded by Mr. Ilgenfritz.

V V

Adolphus O. Brackert, recently elected to the presidency of the American Foundrymen's Association, at its annual convention in Milwaukee, is a native of Cleveland, is vice president and general manager of the Penton Publishing Company, secretary-treasurer of the Foundry Supply Manufacturer's Association and the Molding Machine Manufacturer's Association and secretary of the Foundry Equipment Manufacturer's Association. He has been active in association work for many years.

V V

John J. Agnew has accepted a position with the Mesta Machine Company, Pittsburgh, Pa., on the sales staff in the roll and mill department. Mr. Agnew was connected for several years with the Pittsburgh Iron & Steel Foundry Company, Midland, Pa., as manager of roll sales.

V V

C. P. Perin, who has been connected with the Tata Iron & Steel Co., Calcutta, India, is returning to New York by way of Cape Town and London and was met in London by F. L. Lindemuth.

V V

Harry Urban, formerly superintendent of the Fairfield by-product plant of the Tennessee Coal, Iron & Railroad Co., has been appointed general manager of the Woodward Iron Company.

V V

John J. Muir, for the past 18 years affiliated with the Bass Foundry & Machine Co., has resigned as superintendent of the engineering department, to become general superintendent of one of the largest shipbuilding organizations on the Pacific Coast, located at Seattle.

V V

A. G. Lapierre of the northwestern regional directors office of the United States Railway administration, has been appointed traffic manager for the Chicago Pneumatic Tool Company, with offices in Chicago, succeeding E. H. Greene.

V V

W. W. McMillan, purchasing agent and Frank R. Anderson, assistant for the Malleable Castings Company, were transferred from the Sharon, Pa., works to the main office at Cleveland.

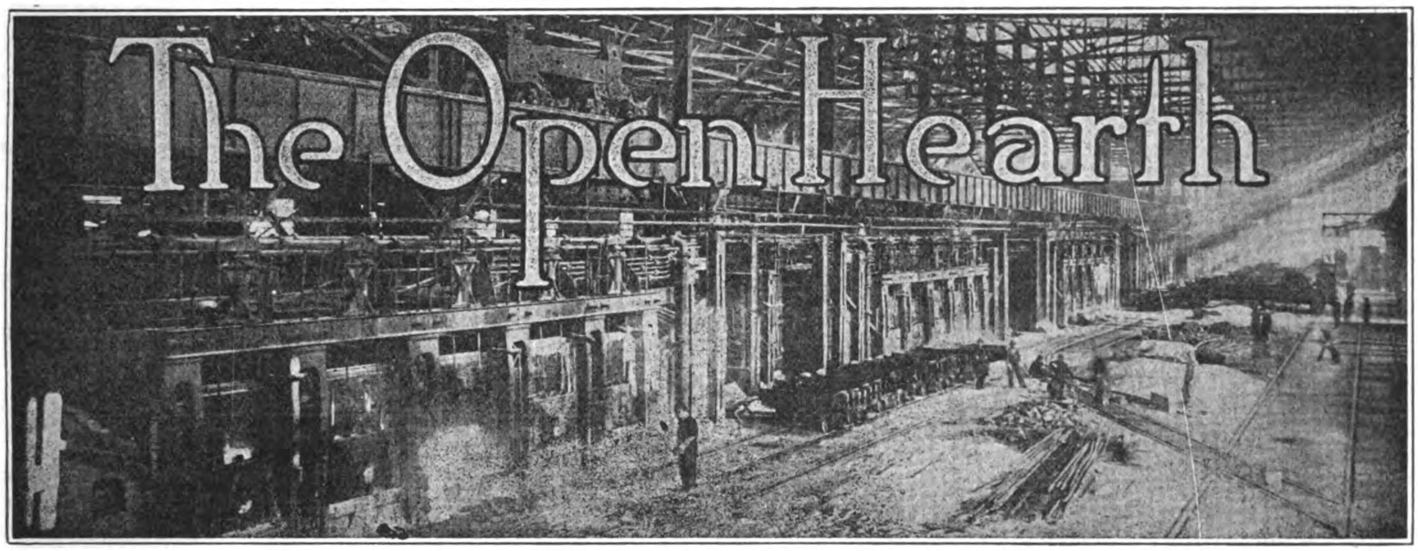
V V

F. L. Estep has become affiliated with the consulting engineering firm of C. P. Perin and S. M. Marshall at No. 2 Rector street, New York. He was formerly chief engineer for the Nova Scotia Steel & Coal Co, Ltd., New Glasgow, N. S.

V V

Thomas MacDonald, consulting engineer of the Carnegie Steel Company, Youngstown district, has been made chairman of the Youngstown Council of National Defense com-

The Open Hearth



mittee to supervise new construction to comply with the new ruling, that no new progress involving an outlay of more than $2,500 may be undertaken without Federal permission.

V V

Seymour Wheeler has been accepted for training at the officers' camp at Zachary Taylor, Louisville, where he will train for service in the field artillery. He was treasurer for Pickands, Brown & Co., sellers of pig iron and ferro-alloys.

V V

Willis Warner has been appointed general chemist and placed in charge of the open hearth and blast furnace labor laboratories, for the Republic Iron & Steel Co., to succeed T. J. Davies, resigned. Joseph Mayberry succeeds Mr. Warner at the Bessemer laboratories.

V V

William J. Priestly, division superintendent of the forge, machine shops and founderies for the Bethlehem Steel Company, at Bethlehem, Pa., has resigned.

V V

Dwight D. Miller has been appointed manager of New York office of the Electric Furnace Company, Alliance, Ohio, recently opened in Room 1806, 15 Park Row.

V V

Charles M. Smith has been appointed superintendent of the foundry operated by the Nelson Bronze Company, Saginaw, Mich. He was formerly affiliated with the Michigan Steel Casting Company, and Detroit Steel Casting Company, of Detroit.

V V

Charles B. Wilson, vice president and general manager of the Ferro Machine & Foundry Co., of Cleveland, has been elected a director, with the office of vice president in charge of production for the Curtiss Aeroplane & Motor Corp., Buffalo, N. Y.

V V

R. J. Mullaby has been named superintendent of the MacDonald Bar Mills of the Carnegie Steel Company, Youngstown, Ohio, to succeed W. U. Dennison, transferred to other work.

V V

H. L. Mode has been appointed manager of the crane department for Young, Corley & Dolan, Inc. He was formerly sales engineer in the crane department of Manning, Maxwell & Moore.

V V

Capt. Paul Llewellyn of the Interstate Iron & Steel Co., Chicago, who was commissioned in the gas defense division of the chemical warfare service, in the United States army, has recently received his commission as major, the same service.

V V

Willard E. Freeland, for three years New England editor of the Iron Age, has resigned to accept the position of assistant to General Manager John E. Otterson of the Winchester Repeating Arm Company, New Haven, Conn.

V V

Robert I. Clegg, vice president of the Gardiner Printing Company, Cleveland, formerly editor of Castings, has been appointed New England editor for the Iron Age.

V V

J. F. Shea has been made works manager for the Delta Machine & Foundry Co., Brooklyn. He was formerly foreman of the pattern shop operated by the Lake Torpedo Co., Bridgeport, Conn.

V V

Henry A. Butler, chief of the order department for the Youngstown Sheet & Tube Co., Youngstown, Ohio, expects to sail shortly for Europe to do Red Cross work.

V V

A. E. Brown, formerly general manager of the Chicago and Alton Railroad at Detroit, has been appointed manager of the railroad department of the Truscon Steel Company, Youngstown, Ohio.

V V

George H. Aykrod has been made superintendent of the 12 and 18-inch mills of the Saucon plant of the Bethlehem Steel Company, South Bethlehem, Pa. He was until recently, superintendent of the rolling department of the Pittsburgh Crucible Steel Company, Pittsburgh, Pa.

V V

C. B. Cushwa, for the past 17 years general superintendent of the Youngstown Iron & Steel Co., and its successor the Sharon Steel Hoop Company, Youngstown, has been appointed general superintendent of finishing mills for the Brier Hill Steel Company, Youngstown.

V V

E. L. Tuck has been engaged by the Dayton Molding Machine Company, Dayton, Ohio, in an important sales capacity. Mr. Tuck was formerly superintendent for T. McAvity and Sons, Ltd., St. John, N. B., Canada.

V V

J. Leichman, formerly with the American Locomotive Company, Schenectady, N. Y., was recently appointed superintendent of the foundries operated by the Rathbone-Sard & Co., at Albany, N. Y., and Aurora, Ill.

WITH THE EQUIPMENT MANUFACTURERS

SMOKE PREVENTION, COAL SAVING SUGGESTIONS

Just at this time when the conservation of coal is an absolute necessity and every practical suggestion for such conservation is a shot at our enemy, everyone realizes that smoke issuing from boiler stacks represents unused heat units, but everyone does not realize that certain simple rules, if observed in the fire room, will materially decrease this loss. The suggestions herein are based on many years' experience of the Westinghouse Electric & Mfg. Company's combustion engineers and are briefly outlined below.

1. Give your fireman an opportunity to acquire the fundamental principles of fuel burning.
2. If you have a difficult fuel problem, consult a combustion engineer.
3. Prevent smoke by proper firing methods.
4. Use gauges to indicate exactly the condition of firebed at all times. As a minimum these gauges should consist of draft gauge indicating draft in furnace above fuel bed, draft gauge indicating draft at boiler side of flue damper and a steam flow meter for individual boilers.
5. CO_2 is the principle product of complete combustion of coal. Ten to twelve per cent CO_2 should be obtained in flue gases to insure minimum fuel loss.
6. Avoid loss due to unburned coal in the ash.
7. If you are wasting exhaust steam, you are wasting coal.
8. Do not permit grates to clog. A systematic method of keeping the air spaces clean must be followed.
9. Inspect the baffles in boilers as broken or leaky baffles raise the flue gas temperature and waste coal.
10. Avoid leaking in of cold air around boiler setting.
11. Install stokers. Hand firing is rapidly being recognized as an obsolete and wasteful method of firing.
12. Clean scale from tubes as every particle of scale represents wasted coal.
13. Avoid soot formation. All boiler tubes should be blown externally once every eight hours when in continuous service.
14. All smoke flues should be as short and straight as possible. Flues should also be made air tight and all joints and connections should be well fitted, caulked and riveted. Use asbestos gaskets on cleanout doors.
15. Locate flue dampers in front of boiler so that fireman will adjust them as required. Dampers located in rear of boilers are seldom disturbed regardless of conditions.
16. The size of coal has much to do with capacity and efficiency of boilers. In general, the air pressure penetrates the fuel bed formed by coarse coal easier than that formed by finer coal, resulting in disturbance of best furnace conditions.

In addition to the above suggestions, the following "don't fail to do" list should be followed.

Don't fail to:

Keep the heating surfaces of the boilers free from soot, scale or oil.

Keep the fires level and free from holes.

Do not carry the fires so thin as to draw a lot of excess air through.

Do not carry the fires so thick as to have incomplete combustion of the coal.

Do not soak the coal with water before firing.

Be sure the blow-off valves do not leak.

Do not have the safety valve popping off continually.

Cover steam pipes.

Do not waste steam through leaky valves or traps.

Never use live steam if exhaust steam is available and can be used as well.

An observance of the foregoing simple rules and suggestions should materially reduce the coal consumption of the average plant.

WALL TYPE SWITCHING UNIT.

A new wall type switching unit for the control of alternating current circuits up to 300 amperes and 2,500 volts has been brought out by the General Electric Company. The unit consists of an industrial type oil circuit breaker with a space above which serves as a housing for disconnecting switch, current and potential transformers and also provides a location for either volt-meter or ammeter or both when desirable.

Following along the lines of safety-first principles, the disconnecting switch is interlocked, mechanically, with the oil circuit breaker so that the switch cannot be opened when the breaker is closed, nor can the breaker be closed while the disconnecting switch is open. A key projecting through the front of the panel is used to operate the disconnecting switch. This key can be removed when the switch is open, and carried by the operator who then is assured that no one will close the switch while he is working on lines or apparatus on the circuit controlled by this unit. The interior of the switch compartment is inaccessible while the switch is closed and the oil tank cannot be removed while the disconnecting switch or oil circuit breaker is alive.

These switching units are particularly adapted to the control of circuits feeding banks of transformers; motors in steel mills and pumping plants, where it is desirable to mount the motor control appliances on walls or pillars.

The units are self-contained and may be considered as "safety first" in every particular.

Wall type units are designed for single or group mounting and have a large bus compartment just above the disconnecting switch and inside the cast iron housing. Conduit connection with the unit can be made from above, below or from either side.

CAR SWITCH ELEVATOR CONTROL.

Single-speed passenger and freight elevator service requiring car-speeds up to 150 feet per minute can be successfully handled by Westinghouse type E elevator control, which is used with compound-wound direct-current elevator motors.

The control is quiet in operation and the car on which it is used is always under complete direction of operator. Some of the features of type E control panel are, (1) the directional contactors mechanically interlocked, (2) line contactor, (3) accelerating contactor, (4) contacts interchangeable, (5) accelerating contactor is electrically interlocked with directional contactors, (this prevents damage to motor from reversing without starting resistance in circuit), (6) flexible shunt relieves all bearings from carrying current, (7) dependable time element dashpot, (ratio between resistance steps cannot be tampered with) (8) adjustment for time of acceleration easily made, (9) resistor mounted on panel, (10) all apparatus mounted on pipe frame-work.

The acceleration is smooth and uniform, being effected automatically and thus entirely independent of the operator,

WITH THE EQUIPMENT MANUFACTURERS

it is impossible to injure the electrical apparatus by careless or ignorant manipulation of a car switch.

The control is designed with time limit acceleration with capacity for handling 10 H.P., 115 volts, or 20 H.P., 230-550 volts direct-current motors.

The apparatus is very simple, consisting of a control panel, a car switch and such elevator safety devices as may be desired.

The switch closes the circuit through the contactors, a shunt circuit energizes the brake magnet and releases the brake. If the car switch is returned to the "off" position, or if any of the safety devices operate, the control circuit is opened, the brake magnet is deenergized, and the brakes are immediately applied.

The safety devices most commonly used are the emergency switch to be used by the operator in case of accident to the car switch; machine-limit and hatchway-limit switches, which operate automatically to prevent accidents from overtravel should the operator for any reason fail to release the car switch; and door interlocks, which prevent the starting of the car until the door is properly closed.

The car switch elevator control (type E) is used with alternating current squirrel-cage motors of 20 horsepower, with a maximum of 220-440-550 volts. It is of the 25 and 60 cycles, 2 and 3 phases type.

STEEL GRIP GLOVES.

A new steel-grip glove has been placed on the market by the Halcomb Safety Garment Company, of Chicago, Ill. The glove proper is made of chrome leather and sewed close with steel thread. This means that the glove is rip-proof. Men working at the hammer and furnace handling hot steel experience a good deal of trouble with their ordinary cloth gloves tearing or burning through. In the above style glove this is practically impossible and their palms, fingers and thumbs are reinforced with small steel ribbons. They are clinched with a patented process so that the workman cannot hurt his hand. This type of glove is flexible, pliable and comfortable and can be used not only by men at the furnace but by the men handling stock in the shop or steel shed. These gloves are approved by a number of safety engineers in the country and reports show that they prevent accidents and incidentally costly delays in production.

ENAMELED RESISTANCE UNITS FOR CURRENT REGULATION.

Enameled resistance units for regulating current have been developed in various forms and sizes by the General Electric Company of Schenectady, N. Y. Some of the applications to which these units have been put are railway and fire alarm signals, fractional horse power motors, and locomotive headlights. They are also used extensively in series with relay, contactor and circuit breaker coils on panels and switchboards. They will be found particularly applicable in mines and similar places where a great amount of dampness and moisture are present. These units are unique in their ability to withstand unusually high temperatures as well as sudden changes in temperature from one extreme to the other.

The resistance wire or conductor is wound either upon a steel body coated with a special refractory enamel or paint and high heat resisting silicate compound developed to withstand sudden extreme temperature changes without cracking or weakening or in any way being injured. The steel body is preferred for extreme lengths where strength for a long span is required and is especially serviceable where the unit might be subjected to severe vibration or shock.

The refractory silicate body is used for most of the ordinary types of resistance. The compound employed is far superior to porcelain or any equivalent ceramic products which are easily cracked or weakened mechanically by repeated and extreme temperature fluctuations.

After being wound upon the proper body the conductor is embedded in a blue vitreous enamel and is fused until it has a uniform glossy structure, at a temperature of about 1,000° C. This enamel is moisture and heat resisting and forms a mechanically strong casing for the conductor. Enamels of the type used are extremely durable and maintain their dielectric strength and mechanical properties indefinitely.

SQUIRREL CAGE ELEVATOR MOTOR CONTROL.

An elevator control to be used with squirrel cage motors in sizes up to and including 20-horsepower at car speeds not exceeding 150 feet per minute has been built by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., for both freight and passenger service.

The equipment of this elevator control, type E, i sextremely simple, consisting of a small control panel mounted on the wall somewhere near the motor, a car switch, by means of which the operator controls the movement of the elevator cars; and such elevator safety devices as may be desired.

A line contactor and two mechanically interlocked directional contactors are mounted on a black marine finished slate base. The motor, being started with full line voltage, requires no secondary or accelerating contactors.

The equipment of this elevator control, type E, is extreme-operation. All parts are easily accessible for inspection or repairs. The contacts are graphite to graphite of the butt type (no sliding contacts used), and are interchangeable for the various contactors.

The same contacts may be used for alternating-current and direct-current type E controllers for both car-switch and push-button operation.

The car switch closes the line contactor and one of the directional contactors, and thus starts the car in the desired direction.

A black marine finished slate panel is furnished with a pipe frame for floor mounting, and carries a main-line contactor, two directional contactors, which are mechanically interlocked, and an accelerating contactor, controlled by a large air dash-pot for cutting out the starting resistance and series field. The resistors are mounted on the rear of the panel, making the control apparatus a complete unit which can be mounted in any convenient place near the elevator motor, and rendering all parts easily accessible for inspection at any time.

Provision is made on the directional and line contactors for a shunt brake circuit, which, when the control circuit is completed, energizes the brake magnet and releases the brake.

Trade Notes

E. P. Cooke has assumed the duties of sales manager of the Fawcus Machine Company with headquarters at their Pittsburgh office. Mr. Cooke still retains his interest in the Armstrong-Cooke Steel Company which he organized after leaving his engineering position with the Corn Products Company of Chicago.

Freyn, Brassert & Co. and employes have subscribed the sum of $33,700.00 to the Fourth Liberty Loan. The total amount of Liberty Bonds of all issues held by the firm of Freyn, Brassert & Co. now amounts to $100,000."

Freyn, Brassert & Co. have licensed the Pittsburgh Crucible Steel Company to install and use on the new blast furnace now building at Midland, Pa., a Brassert patented gas washing and drying unit for cleaning the total gas of this furnace. This brings the total number of Brassert gas washing and drying units to 64.

Morris & Company of Chicago, have just placed an order with the Locomotive Pulverized Fuel Company, 30 Church street, New York, for equipping their steam power plant at Oklahoma with a complete "Lopulco" system for crushing, drying, pulverizing and burning coal. They expect to use native coals and to make use of Texas lignite. The power plant contains seven Edgemoor boilers having a total of 3,100 horse power, all of which are to be equipped.

Trade Publications

Valve Control—"Facts" is the title of the new eight-page two-color descriptive booklet recently issued by the Cutler-Hammer Manufacturing Company of Milwaukee and New York, which illustrates and describes the Dean valve control and its application to large valves. The booklet lays special emphasis on the fact that by the application of Dean valve control to water mains at strategic points a great deal of the damage caused by bursting water mains may be averted. The Dean valve control consists of a high torque motor which opens and closes the valve gate, a limit mechanism which automatically disconnects the motor at the completion of the gate travel and one or more remote control stations from which the valve can be operated. The valve operating mechanism can be attached to the valve while it is in service and without affecting the service. This control system can also be adapted to large screw type valve and may be used for either municipal or industrial applications where it is desirable to open and close the valve rapidly or to have the control of the valve located somewhat distant from the valve itself.

Gates—The Beaumont Manufacturing Company, Philadelphia, Pa., has issued Catalog 37, giving descriptions, illustrations and dimensions of standard Beaumont gates for controlling the flow of granular materials from bunker. The design of ash pits under boilers and the correct gate to use for this purpose are illustrated.

Gas Producer Agitators—Chapman Engineering Company, Mt. Vernon, Ohio. Bulletin No. 8, describes their floating agitator with automatic feed for bringing up-to-date old-style hand-operated gas producers. It is claimed that this machine, installed on any hand poked producer, approximately doubles its capacity, improves the quality about 30 per cent, eliminates hand poking and gives a very uniform flow of gas. Some of the distinctive features are: 1. The coal falls evenly upon the entire fire bed simultaneously. 2. The rotating feed drum is built on a slight taper so that the clearance between it and the casing may be easily adjusted to prevent leakage of gas. 3. The slicing bar or agitator "floats" up and down with the fire-bed, thus adapting itself automatically to the varying height of the fire-bed. 4. A special tooth roller is provided in the coal hopper to prevent the hanging up of fuel. It also serves as an auxiliary coal crusher. Remarkable results obtained in various steel works are given. The bulletin is an attractive sample of printing.

C-H Standard Attaching Devices is the title of the new two-color envelope folder being distributed by the Cutler-Hammer Company of Milwaukee. Special emphasis is given to the fact that the C-H "Standard" Attaching Cap fits all C-H "Standard" plugs and receptacles as well as the standard plugs and receptacles of five other leading manufacturers. The folder illustrates 21 of the various attaching devices manufactured by this company. They include numerous types of flush, surface, conduit fitting, and metal mounting receptacles, besides motor attachment plugs, cord connectors and current taps. These devices have the N. E. C. "standard" rating of 10 amperes, 250 volts with the exception of the standard attachment plug and current taps which have the maximum screw shell or socket rating of 660 watts. The folder lists the complete line of attaching devices, giving carton and standard package quantities, and price of each catalog number. The usual space is provided on the first page of the folder for dealers' and jobbers' imprint.

Soldering Irons—Two descriptive leaflets illustrating and describing C-H Soldering Irons and C-H Automatic Safety Racks for electric soldering irons, have recently been issued by the Cutler-Hammer Company of Milwaukee, Wis. These leaflets are known as Publication 403 and 404. The former enumerates the advantages to be secured through the use of an automatic safety rack. This rack keeps the iron at a safe temperature between periods of use; allows full current to flow as soon as the iron is lifted from the rack; insures against fire and waste, and speeds up work.

The latter points out that war time work requires efficient tools and as such, the electric soldering iron consumes no fuel or current, except when in actual use; does not vitiate the air; is safe for both the experienced and inexperienced employe, and reduces fire hazard.

Heat Treating Furnaces—The Tate Jones & Co., Inc., furnace engineers, Pittsburgh, have just published a new catalogue which describes and illustrates their furnaces of large capacity. Many interesting illustrations appear in the booklet.

Graphite—The United States Graphite Company, Saginaw, Mich., has just issued a new general catalog, No. 201. This booklet contains detailed information relative to lubricating graphite, greases, paints, etc., in addition to the product prepared especially for use in the steel industry. It also includes a group of micro photographs and a report of an exhaustive test made by Mr. Willis Lawrence, chief engineer of the Interborough Rapid Transit Company of New York, both of which are of great interest.

Obituary

Frank I. Parker of the Cutler-Hammer Manufacturing Company, Milwaukee, Wis., died at his home in Milwaukee on October 18, at the age of 36 years. His death was due to pneumonia contracted through Spanish influenza. Mr. Parker was graduated from the University of Wisconsin in June, 1906, and in July became engineer in charge of production in the Magnet and Clutch Department of the Cutler-Hammer Company. His early work was with lifting magnets made by this company being responsible for many of the exclusive features of these magnets as well as designing several of its magnet and motor-operated brakes. Since 1911, Mr. Parker has had charge of sales service work on Clutch Department products. He was made an associate member of the American Institute of Electric Engineers in 1910 and in 1913 became a member. He is survived by his widow and one child.

Chas. F. Forster, 335 South Grove avenue, Oak Park, Illinois, president of the Forster-Waterbury Malleable Iron Works, Franklin Park, Illinois, died October 15 of a complication of diseases. Funeral services were held at the residence and the body was shipped to Pittsburgh, Pa., for interment in Uniondale cemetery. He is survived by his widow, Mrs. Nancy Reid Forster and two children, Mrs. Sherwood Haines and Thomas H. Forster. He was for many years with the Carnegie Steel Company, at the Homestead Steel Works, Homestead, Pa., but later was with the Iroquois Furnace Company, at South Chicago. At the time of his death he was a member of the Forster-Waterbury Malleable Iron Works at Franklin Park, Illinois.

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The Blast Furnace and Steel Plant

Pittsburgh, November, 1918.

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